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SECTORAL STUDY

Vegetables: Open-Field and Greenhouse Production

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PLANNING AND IMPLEMENTATION :
AGRICULTURAL UNIVERSITY OF ATHENS

The program NEW AGRICULTURE FOR A NEW GENERATION is

Led by:
RUTGERS
School of Environmental and Biological Sciences

In partnership with:
AGRICULTURAL UNIVERSITY OF ATHENS
AMERICAN FARM SCHOOL

Implemented through an exclusive grant by:
ΙΣΝ/SNF ΙΔΡΥΜΑ ΣΤΑΥΡΟΣ ΝΙΑΡΧΟΣ
STAVROS NIARCHOS FOUNDATION

«Recharging Greek Youth to Revitalize the Agriculture and Food Sector of the Greek Economy»

Final Report

Sectoral study 5

Vegetables: Open-Field and Greenhouse Production

Athens, December 2015

Study 5: Vegetables: Open-Field and Greenhouse Production

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Summary

The share (%) of vegetables, fruits and other horticultural plants, based on production value at basic prices, amounted to 39% of the total agricultural output, which totaled € 9.7 billion in 2014. About half of this share corresponds to vegetables. This data highlights the importance of the vegetable sector for the Greek agro-food sector. The present study provides an overview on the vegetable production sector in Greece, focusing on both open-field and greenhouse crops. Greece is characterized by mild winder climate and is, therefore considered an ideal site for economically viable seasonal and off-season production of vegetables. In the last few years, an appreciable number of young people, many of them with a medium to high education level, are interested in starting an agricultural enterprise. However, starting a new vegetable production business, for which the know-how is limited, puts forward many questions about several technological and economic aspects. Taking this background into consideration, the present study was commissioned to address these questions and provide a sound information basis for the establishment of viable enterprises in the sector of vegetable production. Furthermore, know-how regarding the application of good agricultural practices and certified production is provided, given that the latter is currently a prerequisite for selling in the international food market. The main objective of the present study is to support people who are interested in starting a new enterprise in the sector of modern vegetable production in Greece.

The prospects of economically viable seasonal and off-season vegetable production in Greece are outlined based on available statistical data, interviewing of vegetable growers, agronomists and relevant literature sources. The study is based on statistical data provided by the Greek Ministry of Rural Development and Food, the Greek Statistical Authority, and other sources, about the cultivated area and the total production of most commercially grown vegetables, as well as the areas and amounts of vegetables grown under cover and especially in greenhouses. Furthermore, data about the values of fruit and vegetables imported and exported are presented and discussed, while the factors hampering the further expansion of exports are highlighted. Special emphasis is put also on the opportunities to increase exports. In addition, the present study includes a complete description of two important vegetables, particularly tomato as representative for greenhouse production and lettuce as representative for open-field vegetable production.

The study includes also a discussion section, where the capacities and prospects of vegetable production in Greece as a whole and at regional level are summarized. Furthermore, the opportunities in the vegetable production sector for new and experienced growers, issues related to the domestic market and consumer habits, the export potential, the opportunities for Greek-produced vegetables to substitute for exports, the possibilities for E-commerce in vegetable commodities, and the prerequisites to entrepreneurial success in the vegetable sector are also addressed in the discussion sector, together with a stakeholder analysis. Finally, the main body of the study concludes with some brief recommendations to be considered in the implementation phase.

In addition, a full description of the current status and the opportunities to grow all greenhouse and open-field vegetables that are, or may be, economically important for Greece is provided in an Appendix. Furthermore, the study includes two business plans for two typical vegetable production enterprises, particularly greenhouse production of tomato in a modern soilless culture system and open-field production of lettuce. These two case studies include a cost analysis, financing opportunities, anticipated revenues, and an overall viability analysis for the first five production years.

Additionally, the present study includes as a second appendix a technical guide for greenhouse production in some alternative hydroponic systems (mainly soilless culture on substrates, but also water culture systems such as aeroponics, floating hydroponics, NFT, vertical hydroponics) in form of a Power Point presentation.

1. Introduction – Determining the vegetable production sector

Vegetables are annual or perennial herbaceous plants whose fruit, seeds, roots, tubers, bulbs, stems, leaves, or flower parts are used as food in fresh condition, frozen or conserved and are rich in juice, minerals, vitamins and fiber.

The plant species that are commercially cultivated as vegetables in Greece and included in the statistics of the Greek Ministry of Rural Development and Food are shown in Table 1.1. The criterion used to characterize a plant as a vegetable is not the plant species but the applied cultural practices and especially the form in which this is consumed after its harvest. Vegetable is a plant that is cultivated in order to be consumed as fresh, frozen or canned food. On the contrary, when the same plant is cultivated in order to be dried or mashed, then it is not considered a vegetable. For example, common bean (*Phaseolus vulgaris* L.) is considered a vegetable when it is cultivated to produce green pods intended to be consumed if fresh condition or after freezing. In contrast, the same plant species is not considered a vegetable when it is cultivated to produce dry seeds (pulses). Another example is tomato; when tomato is intended for fresh consumption, then it is considered a vegetable. However, when it is produced to be mashed and canned it is not considered a vegetable but an industrial edible plant (processing tomato).

The cultivation practices applied to plants used to produce fresh food are different than those needed to produce dry seeds or raw material for the relevant industry. For example, when a tomato crop produces fruit intended to be consumed as fresh vegetable, repeated harvesting every 2-3 days is applied manually over a longer period, so as to avoid injuries that might minimize the external fruit quality. However, processing tomato is collected once using specialized harvest equipment. Furthermore, the cultivars used when a species is cultivated as vegetable are different that those used for dried seed production or industrial processing.

Vegetables are consumed mainly in fresh condition or after freezing rather than as canned food or food conserved in any other form. This is so because: a) their consumption aims at covering specific nutritional needs by ingredients that are destroyed when vegetables are processed (i.e vitamin C) and b) fresh vegetables are very tasteful. This means that the most vegetables should be traded and consumed within few days not exceeding one week after their harvest. Consequently, vegetables have to be produced constantly over the whole year, excluding those traded after freezing or conservation. Given that vegetables – as all cultivated plants – have specific needs in environmental conditions in order to be developed (temperature, humidity, light), their cultivation is not possible throughout the year everywhere. On the other hand, in our era the demand for the majority of vegetables is constant all over the year and not seasonal.

Table 1.1. Total cultivated area and total production of commercially grown vegetables in Greece as recorded by Greek Ministry of Rural Development and Food for 2014.

	Open Field		Protected cultivation*		Total	
Vegetables	Area (ha)	Production (tn)	Area (ha)	Production (tn)	Area (ha)	Production (tn)
Artichoke	1,877	11,337	0	0	1,877	11,337
Asparagus	2,039	7,246	0	0	2,039	7,246
Beetroot	638	8,671	0	0	638	8,671
Cabbage	5,644	117,374	0	0	5,644	117,374
Carrots	1,355	43,780	0	0	1,355	43,780
Cauliflower-Broccoli	4,081	58,004	0	0	4,081	58,004
Celery	666	7,060	0	0	666	7,060
Celery root	37	438	0	0	37	438
Chard	129	813	0	0	129	813
Chicory	1,334	10,436	0	0	1,334	10,436
Cowpea	51	321	0	0	51	321
Cucumber	919	16,430	1,588	165,782	2,507	182,212
Dill	588	4,220	0	0	588	4,220
Eggplant	1,933	30,024	357	22,310	2,290	52,334
Endive	595	4,174	0	0	595	4,174
Garlic	1,419	8,175	0	0	1,419	8,175
Green beans	5,885	46,264	406	9,876	6,291	56,139
Green peas	3,158	15,681	0	0	3,158	15,681
Leek	1,475	23,031	0	0	1,475	23,031
Lettuce	4,202	42,066	574	7,820	4,776	49,886
Melon	4,087	66,234	686	12,679	4,773	78,913
Okra	1,437	7,547	0	0	1,437	7,547
Onions	7,101	197,785	0	0	7,101	197,785
Parsley	549	5,757	0	0	549	5,757
Pepper	3,135	55,284	1,089	92,624	4,224	147,908
Potato	24,631	585,975	0	0	24,631	585,975
Radish	162	1,220	0	0	162	1,220
Spinach	3,861	33,582	0	0	3,861	33,582
Tomato	8,907	205,018	3,064	345,027	11,972	550,045

Watermelon	9,705	447,377	2,815	90,942	12,520	538,319
Zucchini	2,737	36,820	567	20,120	3,304	56,940
Total	104,338	2,098,144	11,145	767,180	115,484	2,865,323

* Protected cultivation includes both low tunnels and tall greenhouses.

The continuous demand for vegetables all over the year generates a high demand for imports and exports of vegetables from country to country, thereby creating a huge international commerce of vegetable products. It is worth mentioning that EU has an annual shortage of vegetables totaling € 12.8 billion and annual imports of vegetables approaching € 20 billion mainly from USA, Turkey, North Africa, Middle East, South Africa and Latin America. These needs in the international market create great opportunities for production and export of vegetables form countries with mild climate such as Greece, even when the relevant knowhow in many of these countries is inferior to that of the developed countries. On the other hand, exactly for the same reasons, vegetable production and export companies in Greece are exposed to competition from other countries with similar or more favorable climatic conditions and lower technological and economic level. Hence, further improvement of the current knowhow along with appropriate policies for the support and encouragement of domestic production are needed in order to take advantage of the favorable pedo-climatic conditions for high-quality vegetable production.

The overall improvement of living standards in most countries during the last decades was accompanied by a tremendous increase in the demand for out of season vegetables. As a result, investment in greenhouse enterprises has increased. In more developed colder regions of the north, new investments in greenhouses have been directed mainly at the improvement or replacement of existing equipment and the introduction of innovative technologies. These include high greenhouse constructions, new covering materials, computerized climate and nutrition control, hydroponics, greater mechanization, energy conservation, integrated pest management, genetic engineering etc. The comparatively high revenue per square meter that may be obtained in such high-tech greenhouses has encouraged the introduction of these sophisticated, but expensive, technologies.

2. Current state of vegetable production in Greece

2.1. Current state of vegetable production – An overview

Vegetable production generates high economic returns per unit of land, offering good income prospects for small holders, especially in areas where land is scarce. Therefore, vegetable production is internationally a very important pillar of the primary sector and the food production. According to FAO data (2010), the total area occupied by vegetable crops all over the world was 57 million hectares in 2014 whereas during the same year the global vegetable production reached the level of 1 billion tons. The global vegetable production in 2010 increased by 33% in comparison with that recorded in 2000. This difference indicates an increasing trend of the vegetable production sector internationally, which has to keep pace with the increasing population rate.

The total area of Greece is about 132,000 km^2 (13.2 million hectares). Nearly 31.5% of this area, which is about 4 million hectares, is exploited as agricultural land (European Union, 2013). Of this area, approximately 115,000 ha, which corresponds to 2.9% of the total cultivated land, is used for vegetable production (Table 1.1). This percentage however does not reflect the relative contribution of vegetable production over the total domestic agricultural output, because vegetable crops are intensive and thus they produce much higher values per agricultural land unit than most of the other crops and especially cereals and fodder crops. According to EUROSTAT (News Release, 2015), the share of vegetables, fruits and other horticultural plants in percentage, based on production value at basic prices, amounted to 39% of the total agricultural output, which totaled € 9.7 billion in 2014. About half of this share corresponds to vegetables. Indeed, as reported in a relevant study of "GAIA ΕΠΙΧΕΙΡΕΙΝ" (2015), the highest percentage in the total value of the domestic agricultural production during 2009-2013 corresponds to vegetables with 18%, followed by fruit production with 16.6%. In 2014, the total vegetable production in Greece was approximately 2.9 million tons with an estimated value of 1.75 billion.

As shown in Table 1.1, the most important vegetable crop species in Greece based on cultivated area in 2014 were: potato with 24,631 ha, watermelon with 12,520 ha, tomato with 11,972 ha (excluding processed tomato), onion with 7,101 ha, green beans with 6,291 ha, and cabbage with 5,644 ha. In terms of total production, the highest amounts were obtained from potato (585,975 tons in 2014). However, if one takes into consideration the value of the produced vegetables, then tomato is by far the most important vegetable crop in Greece. Cucumber and pepper are also very important vegetables based on their value.

Open-field crops account for the major part of vegetable production in Greece, even for plant species which are largely produced in greenhouses (e.g. tomato, cucumber, lettuce, etc.). Despite the grave economic situation of Greece during the last 6 years, cultivation areas and production of field vegetables remained more or less to the same levels as before, presumably because their consumption was also not restricted by the economic crisis. Similarly, farmer prices per product unit or per area unit did not substantially alter, while the exports remained constant or even increased, as will be shown by data presented individually for each vegetable species in Annex. Consequently, one can assume that, in contrast to other production sectors in Greece, field vegetable production was not seriously impaired by the economic recession.

Nevertheless, the sector of field vegetable production should be re-organized. Many smallscale farmers cannot cope with the increasing demands of the markets, while the land ownership is highly fragmented as 95% of the farms for horticultural produce have an average area of 0.1-0.4 ha (Rigakis, 2012). The main constraints for Greek open-field vegetable producers is the average yield level due to limited knowhow and the difficulty to promote their produce to international markets due to their small size in combination with inefficient organization in larger cooperatives. On the other hand, the production cost is high, while the prices for field vegetables in the domestic market, especially those produced when there is adequacy in the markets, are invariably low. Thus, profits are minimized and many field vegetable producers in Greece are only marginally viable.

On the other hand, due to favorable climatic conditions for open field vegetable crops even during the cool season of the year, Greece has a great advantage to produce early field vegetables of good quality and to export them to Central and Northern European countries in a period when those products are still not available in the markets. This is for example the case with early watermelon production in Western Greece (regional unit of Ilia) and Peloponnese (Regional unit of Messinia), as well as with asparagus in Central and Easter Macedonia. Nowadays, there are several successful attempts from large producers, cooperations and wholesalers to increase vegetable exports, also in highly perishable products such as strawberry, lettuce, asparagus. However, the current economic instability in Greece in relation to the large investments needed to promote exports of perishable field vegetables, may act as obstacles to those efforts.

Most of the warm-season vegetables produced in Greece are cultivated both in openfield during the warm season of the year and under cover throughout the year. The protected cultivation includes both low tunnels and tall greenhouses. The most important greenhouse crops in terms of cultivated area are tomato, cucumber, pepper and strawberry. Other vegetables grown in non-negligible areas in tall greenhouses are eggplant, green bean, zucchini squash, melons, watermelons, and lettuce. Low tunnels are used mainly for early production of watermelon and melon and, to a lesser extent, also of zucchini and strawberries. Greenhouse production takes place usually throughout the year. Due to maintenance of more favorable climatic conditions, a more efficient control of pest and diseases and cultural practices such as pruning and support, and cultivation for longer periods, the greenhouse crops provide much higher yields per agricultural land unit. For example, in 2014, the average yield amounted to 23.02 tons ha^{-1} in open-field tomato crops, while in greenhouses the corresponding yield of tomato was 112.59 tons ha^{-1}, according to statistical data of the Greek Ministry of Rural Development and Food. Moreover, due to their availability in the market also in the cool season, when they cannot normally produced in open-fields, greenhouse vegetables are traded in significantly higher prices compared to the average sales prices of those produced in open fields during the warm season of the year. Nevertheless, the average yields obtained in domestic greenhouses are low when compared with those achieved in modern heated greenhouses in North European countries. For instance, the previously mentioned average tomato yield of 112.59 tons ha^{-1} in domestic greenhouses is compared to 474 kg m^{-2} in the Netherlands, according to FAOSTAT (2012). The much lower yield per unit of cultivated area in the domestic greenhouses is due to the low technological level of the constructions and the equipment, which restrict the possibilities to effectively control the inside microclimate. In addition, the average level of knowhow concerning nutrition and protection is also unsatisfactory. Last, due to inefficiencies in adjusting the inside microclimate and control pest and diseases, the cultivating period in many Greek greenhouses is relatively short and this further decreases the yield performance. A more detailed description of the greenhouse vegetable production in Greece is provided in Section 2.4.

2.2. Current state in quality of domestic vegetable produce

The quality requirements for fresh fruit and vegetables sold in the domestic market or exported to other member states of the European Union are based on common quality standards set by the European Community. On the domestic market, in many cases there is insufficient incentive for producers to improve the quality of their produce. However, when it comes to export, high quality standards have to be strictly followed. Apart from quality considerations, vegetable exports are hampered by the excessively high costs of packaging and transport.

Current cultural practices and produce quality

The average quality of vegetable produce in Greece is below the expectations, when taking into consideration the potential provided by the favorable pedo-climatic conditions. One of the main reasons is the low education standard of many (especially older) growers. Thus, many greenhouse growers still determine fertilizer application rates by a "rule of thumb". In most cases, this practice results in excessive application rates for nitrogen, phosphorus and, less frequently, for potassium. In some cases, excessive application of one or more nutrients is accompanied by an inadequate supply of other nutrients, thereby exacerbating the incidence of single nutrient toxicities or deficiencies, or even resulting in multi-nutritional disorders. Low levels of potassium supply in soilless cultivated tomato plants are associated with ripening disorders, while adequate K improves fruit color and restricts the incidence of yellow shoulder and other fruit color disorders. In contrast to K, an increase in the nitrogen supply to tomato above a standard threshold level may reduce fruit quality by decreasing the sugar content.

Shortcomings in the irrigation management are also responsible for mediocre produce quality, especially in fruit vegetables grown in greenhouses. Efficient irrigation concepts involve frequent watering application at low doses per irrigation event. This strategy prevents large fluctuations in soil water status, which might result in fruit cracking and other quality defects. Furthermore, inefficiencies in pest and disease control also reduce the quality of vegetables. The warm climate accelerates the proliferation of pests and diseases and this may cause serious damages in external quality if intervention is not timely.

Due to the low technological level in the majority of greenhouses, the climate control is inappropriate and this causes plant stress which leads to serious shortages in produce quality, including the occurrence of several physiological disorders (e.g. blossom-end rot, tip burn, fruit cracking, etc.). Furthermore, the lack of adequate climatic control which results in inappropriate temperature and humidity levels within the greenhouse encourages the occurrence of *Botrytis* and other fungal pathogens. Furthermore, under low temperature and light intensity conditions, fruit set may be reduced and inadequate pollination can result in the formation of small and/or misshapen fruit.

Transport

Other factors that restrict sometimes the quality of vegetables produced in Greece are related to their transportation from the field to the point of retail sale. High ambient temperatures during transport and storage result in water losses and high metabolic activity, thereby negatively affecting the quality of vegetables. This problem is worsened from late spring onwards till October. During the warm season of the year, vegetables should be cooled after harvest and during storage. Unfortunately, vegetables destined for the domestic market are not always subjected to cooling during their transport in the warm season of the year. Unrefrigerated trucks are frequently used for the transport of vegetables from the provinces to central wholesale markets of Athens and Thessaloniki. Part of the vegetables coming from production centers to Athens, is subsequently transported back to other provinces, in which the local production is not sufficient, thereby increasing the stress burden. For example, tomatoes transported from Crete to the Central Wholesale Market of Athens by road and ship, are subsequently transported to Chios by road and ship or to Larissa by road. In such cases, the duration of the transportation from the production field to the consumption center may last longer than 3 days, and during this time the transported vegetables (e.g. tomatoes) may be exposed to ambient temperatures.

Packaging and grading

Shortcomings in produce quality may arise also from poor grading after harvest. Produce destined for sale in open-street retail markets may be roughly selected and graded by hand at the point of harvest, or during marketing. Hand-graded vegetables are invariably less homogenous in size, shape and color, while the percentage of produce with blemishes is higher than that of automatically graded and packed vegetables.

Most vegetables destined for sale on street markets (“Laiki”) or in greengrocers’ shops is packed and transported in plastic field boxes or wooden crates. These are reused many times, frequently without washing or sterilization. The size of the crate is often unsuitable for the produce and may result in impact or compression bruising. Cucumbers are usually packed in polyethylene bags, but these provide little or no protection against mechanical injury. More resistant commodities, such as beans, okra and onions, are packed in net bags. There is an increasing trend for the produce sold by supermarkets to be pre-packed in pre-weighed and priced plastic-covered trays, which provide better protection. Courgettes are often marketed with the flower attached to the fruit. Because the floral organs are highly perishable, these reduce the post-harvest life of the produce. Produce for export is graded and packed at packing stations. Export produce is packed and transported in cardboard cartons (vegetables) or in wooden crates provided with a box-liner or cardboard cartons (fruit).

Soft fruit (e.g. cherries and peaches) are also sold on the domestic market in cardboard or wooden containers. Recently, cardboard cartons have been introduced to the domestic market for certain vegetable commodities (e.g. aubergines, melons and peppers).

This is of economic importance for produce that is transported from Crete to Athens since it obviates the need to return the more expensive plastic or wooden crates after marketing. Moreover, the cardboard cartons improve product appearance and reduce mechanical injury.

2.3. Current situation in the vegetable market in Greece

According to data from the Ministry of Rural Development and Food, about 60% of the Greek vegetable production is sold in the domestic fresh-vegetable market, nearly 25% is processed, while about 6-8% is exported. The percentage of vegetables traded through big super markets is increasing in Greece during the last years. As a result, the domestic vegetable market is mainly driven by the wholesalers or super market chains. In most cases, large super market chains negotiate with bigger producers or cooperatives on an individual basis and thus the prices are not depending only on wholesale markets. Vegetable growers in Greece can stock their products in Greece to the following market points:

- Central Fresh Fruit and Vegetable Wholesale Markets of Athens and Thessaloniki. These markets supply mainly professionals in open markets, local groceries, fruits stores and some super markets. The growers either sell directly to wholesalers in an agreed price, or to retailers via the wholesaler who receive an agreed commission.
- Open-air or accommodated areas of wholesale sales, supplying professional salesmen, small local groceries, fruit stores, as well as wandering salesmen.
- Open-air retail markets where the bigger volume of fresh vegetables (70%) is being distributed. The number of open air markets increases over time, as they provide the possibility to producers to sell directly to consumers without the involvement of intermediaries.
- Big supermarkets or greengrocers which are supplied with vegetables primarily through producer-retailer transactions (direct sales) and less through the Central Vegetable Wholesale Markets.
- Wandering salesmen, who in their majority work without a legal permit.

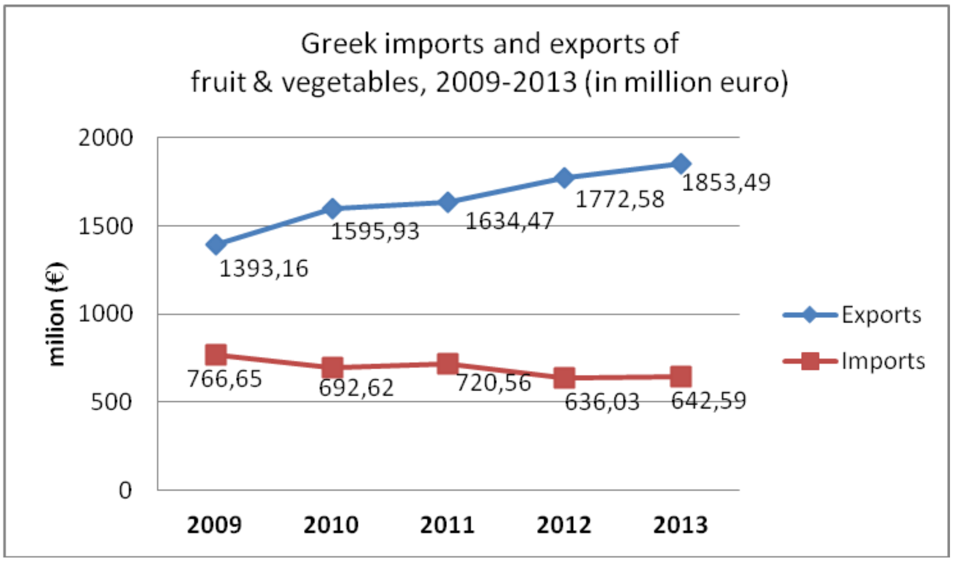

Figure 2.1. Values of fruit and vegetables imported and exported during 2009-2013 (ELSTAT).

Table 2.1. Amounts and values of imported and exported vegetables in years 2009, 2010, 2011 and 2012 (Greek Ministry of Rural Development and Food).

Year	Imports		Exports	
	Tons	Million €	Tons	Million €
2009	206,724	95.40	236,848	106.52
2010	167,657	90.13	317,777	140.09
2011	183,637	105.49	250,605	102.91
2012	150,832	71.42	275,578	126.47

Approximately 10-15% of the country's vegetable production is marketed through the Central Fresh Fruit and Vegetable Wholesale Market of Athens, whereas smaller amounts pass through the wholesale markets of Thessaloniki and other smaller cities in the provinces. The data recorded by the Central Fresh Fruit and Vegetable Wholesale Market of Athens do not distinguish between domestically produced and imported vegetables. In all, however, it is reckoned that less than a quarter of the total domestic vegetable production passes through the wholesale market system.

Despite the favorable climatic conditions, Greece is a net importer of agricultural products. However, with respect to fruit and vegetables, the inverse is true. As shown in Figure 2.1, the value of the imported fruit and vegetables decreased from € 766 million in 2009 to € 643 million in 2013, whereas the exports increased from 1,393 million in 2009 to €
1,853 million in 2013, which resulted in a net surplus of € 1,210 million in 2013. Nevertheless, the contribution of vegetables to the total exports of fruit and vegetables is rather low, ranging between € 103 to 140 million in years 2009-2013 (Table 2.1). Most fruit and vegetables are exported to Balkan countries (Romania, Bulgaria), Germany, U.K., and the Netherlands. A major export market for fresh vegetables within the EU is that of Munich.

The highest amounts of exported vegetables are greenhouse cucumbers, watermelons, and asparagus. The imports and exports of cucumber in the last 15 years are indicatively shown in Table 2.2. On the other hand, the highest imports of vegetables are those of potato. The imports and exports of potato in the last 15 years are shown in Table 2.3. In Sections 3 and 4, the imports and exports of tomato and lettuce, respectively, are also presented. Detailed information about imports and exports of other vegetables are provided in the Appendix.

An important problem encountered by exporters is the high cost of product presentation as well as the transportation cost. The high cost of transportation imposes serious constraints on the competitiveness of Greek vegetable exports to the large fruit and vegetable markets in north European countries. The time involved in handling and transport even from northern Greece is relatively long, and for highly perishable items such as asparagus, the time factor is crucial not only for the transport cost but also for produce quality. Thus, for instance, the mean transport time of white asparagus from the harvest site in Central Macedonia (e.g. the Giannitsa area) to the Central Wholesale Market of Munich was estimated to 174 hours (Siomos et al., 1996). Such a transport time is sufficiently long to cause a loss of weight and quality, even with satisfactory refrigeration during transport. Other EU member states from the Mediterranean basin (e.g. Italy, Spain) do not require sea transport, while the road distance is much shorter. As a result, the time between harvest of vegetables and marketing is less for these countries, and thus the transport cost is lower, while the vegetable quality upon arrival to the market of Munich is higher than for Greek vegetables. Nevertheless, the opening of new markets in Balkan countries provides new opportunities for exports. In these markets, Greece has an advantage over Spain, Italy or the Netherlands, and this has largely contributed to the increase of the fruit and vegetable exports from Greece in the last years.

Table 2.2. Total amounts and values of Greek imports and exports of cucumber during the years 2000-2014.

	Imports			Exports			
Year	Quantity (tons)	price €/kg	Total value million €	Quantity (tons)	Share of production (%)	price (€/kg)	Total value (million €)
2000	0.716	0.42	0.298	14.959	9.23	0.99	14.777
2001	1.064	0.54	0.577	29.267	19.13	0.98	28.540
2002	2.126	0.42	0.892	22.766	13.73	1.24	28.324
2003	5.581	0.47	2.642	23.776	14.79	1.19	28.174
2004	6.069	0.45	2.707	23.087	14.89	0.84	19.474
2005	2.925	0.71	2.089	20.170	12.85	1.25	25.268
2006	2.653	0.68	1.796	24.473	15.83	1.02	25.062
2007	2.226	0.71	1.570	21.697	13.49	0.93	20.171
2008	2.122	0.75	1.586	20.742	12.42	0.87	18.086
2009	1.483	0.85	1.258	17.564	9.96	1.21	21.229

2010	1.051	0.69	0.726	29.354	25.07	0.97	28.439
2011	0.923	0.62	0.576	26.145	16.76	0.74	19.306
2012	0.839	0.59	0.497	30.805	15.80	0.95	29.161
2013	0.839	0.66	0.552	35.058	16.72	0.94	32.979
2014	0.636	0.64	0.409	38.232	20.98	0.78	29.638
Mean	2.083	0.61	1.212	25.206	15,44	0.99	24.575

Table 2.3. Total amounts and values of Greek imports and exports of potato during the years 2000-2014.

	Imports			Exports			
Year	Quantity (tons)	price (€/kg)	Total value (million €)	Quantity (tons)	Exports/ Imports (%)	price €/kg	Total value million €
2000	94.017	0.22	20.590	17.408	18.52	0.20	3.491
2001	69.641	0.24	16.923	18.773	26.96	0.14	2.630
2002	125.386	0.33	41.712	24.813	19.79	0.20	4.962
2003	130.203	0.26	33.540	12.133	9.32	0.18	2.195
2004	123.191	0.29	35.803	24.424	19.83	0.27	6.514
2005	103.558	0.27	27.870	7.789	7.52	0.23	1.800
2006	110.113	0.33	36.494	39.868	36.21	0.32	12.951
2007	121.585	0.35	42.499	32.156	26.45	0.32	10.402
2008	124.201	0.36	44.598	31.307	25.21	0.29	9.168
2009	146.942	0.32	47.410	20.096	13.68	0.31	6.233
2010	108.783	0.34	37.485	26.071	23.97	0.29	7.666
2011	124.148	0.48	59.312	24.369	19.63	0.33	8.123
2012	107.662	0.33	35.606	19.030	17.68	0.27	5.162
2013	122.475	0.44	53.924	18.631	15.21	0.44	8.267
2014	103.961	0.35	36.268	15.348	14.76	0.28	4.340
Mean	114.391	0.33	38.002	22.148	19.65	0.27	6.260

In addition to the long distance, inadequate market, handling and transport infrastructure, as well as a lack of coordination in export activities also set barriers to the export of Greek vegetables to north European countries. The knowledge of export market conditions and requirements is frequently inadequate. Furthermore, the average quality of the exported produce is still unsatisfactory, as indicated by lower market prices on the export market (see for instance the import and export prices of cucumber and tomato in Tables 2.2 and 3.3). This situation points to an urgent need for improvements in the overall produce quality and appearance, more intensive cooperation between growers, exporters and state authorities, and increased contacts with large European supermarket chains.

Consumers' expectations also play an important role in the vegetable market. Especially in the last two decades, vegetable consumers in Greece became more aware of food safety issues and more demanding in quality issues free from any agrochemical residues. This trend started earlier and is stronger in north European countries. The increasing concern of consumers with the safe and quality of fresh vegetables and other food products originating from agriculture, forced the large super market chains in Europe to establish a comprehensive system of certification. This certification system, which was known as EUREPGAP in the past, is now known as GLOBALGAP. The application of the prescribed good agricultural practices is aimed at minimizing detrimental environmental impacts of farming operations, reducing the use of chemical inputs and ensuring a responsible approach to worker health and safety (www.globalgap.org).

Certification of the production procedure according to the GLOBALGAP standard is a prerequisite for the vegetables to be marketed by joined retailers. The introduction of the GLOBALGAP certification system had serious consequences on vegetable production in Greece, since it is currently a prerequisite for vegetable growers who wish to export their products to the large markets of fresh vegetables in central and north European countries. Non-certified vegetables according to GLOBALGAP cannot be exported to international markets. Besides GLOBALGAP, two national systems, AGRO2.1 and AGRO2.2, set up by the National Organization for Certification and Control of Agricultural Products (AGROCERT), are also in use by some vegetable growers. These certification systems however are currently useful only for products traded in the domestic market since they are not recognized in international markets.

2.4. Current situation in protected cultivation of vegetables

2.4.1. General characteristics of protected cultivation in Greece

The term "protected cultivation" includes both tall greenhouses and low tunnels, also known as row covers. The tall greenhouses include high tunnels (arched greenhouses), modified arched greenhouses, plastic-covered greenhouses (low-density polyethylene films and rigid plastic sheets, mainly polycarbonates and PVC), and glasshouses. Low tunnels in Greece are mainly used for early production of watermelon, melon, and to a lesser extent, zucchini squash. Low tunnels for early production of other warm-season vegetables are also used but they cover only minor percentages of the total area under cover.

The development of the greenhouse sector in Greece has centred mainly on an expansion of the area under protected cultivation, while, as a rule, greenhouses are of a simple design. Such constructions, which serve to trap and utilize solar energy, while sheltering plants from strong wind, heavy rain, insects and other pests, has the advantage of low capital investment. Unfortunately, however, the out of season vegetable production under these simple low-tech greenhouses results in relatively low yields and comparatively low percentages of Class I produce. Therefore, it is now widely accepted that technological improvements adapted to the specific climatic conditions must be incorporated into the lowtech greenhouses to make production more competitive. In this section, a more detailed outline of the current situation in the Greek vegetable greenhouse sector is provided.

2.4.2. A short historical overview

The history of greenhouse cultivation in Greece started in 1955. Initially, some glasshouses were established in the Aegean island Syros for cut flower production, followed by similar constructions in Ierapetra, Crete. However, the rapid expansion of greenhouses started in 1961, after the introduction of polyethylene film as covering material. Since that time, the area of tall greenhouses used for vegetable production increased progressively from 3,787 ha in 2001 (Olympios, 2001) to 5,323 ha in 2005 (Table 2.4) and 5,574 ha in 2012 (Table 2.5). Unfortunately, the Greek Ministry of Rural Development and Food could not provide statistical data about the total area of tall greenhouses for 2013 and 2014 but substantial changes are not anticipated.

The use of low tunnels in Greece started also in 1956 and reached a level of 8,128 ha in 1997. In 2005, the area covered by low tunnels decreased slightly to 7,874 (Table 2.4), while in 2012 it dropped to 2,433 (Table 2.5). This decrease was mainly due to a commensurate reduction in the area of watermelon cultivated in low tunnels.

2.4.3. Total greenhouse area and allocation according to crop species

According to data of the Greek Ministry of Agriculture for 2012, only 0.3% of the total cultivated area in Greece is used for protected cultivation of vegetables (including low tunnels) and only 0.14% for vegetable production in tall greenhouses. Nevertheless, greenhouse cultivation is an intensive form of cropping and, therefore, the above percentage is not proportional to its relevance within the agricultural sector of the country. This may be better reflected by the relative contribution of the greenhouse sector to the total gross value of plant production in Greece, which amounts to about 6.5%.

According to statistical data provided for 2014 by the Greek Ministry of Rural Development and Food, the total area of protected vegetable cultivation in 2014 amounted to 11,145 ha (Table 2.6), while the total production obtained from this area amounted to 767,180 tons (Table 2.7). These figures include area and production of both tall greenhouses and low tunnels, while greenhouses used for cultivation of two different crop species within the same year are counted twice. To get a clear picture of the trend in protected cultivation in Greece, the total area cultivated under cover in 2014, as shown in Table 2.6, can be indicatively compared with corresponding data for 2005 and 2012. Thus, in comparison with 11,145 ha in 2014, the total area of protected vegetable cultivation, including both low tunnels and tall greenhouses (1st and 2nd crop) was 10,353 ha in 2012 (Table 2.5), but 14,963 ha in 2005 (Table 2.4). Although the comparison between these three years points to a reduction of the total protected cultivation from 2005 to 2014, this seems to be merely due to a reduction in the area of low tunnels, which dropped from 7,874 in 2005 to 2,433.3 ha in 2012. Although the Greek Ministry of Rural Development and Food could not provide statistical data about the total area of low tunnels in 2014, this was presumably only slightly higher than in 2012. This is indicated by the total area of protected watermelon cultivation, which mostly takes place under low tunnels. Hence, the area of tall greenhouses cultivated with vegetables in 2014 was either similar to or slightly higher than in 2012, and thus also higher than in 2005, which indicates that the greenhouse area in Greece increases slowly but constantly over time.

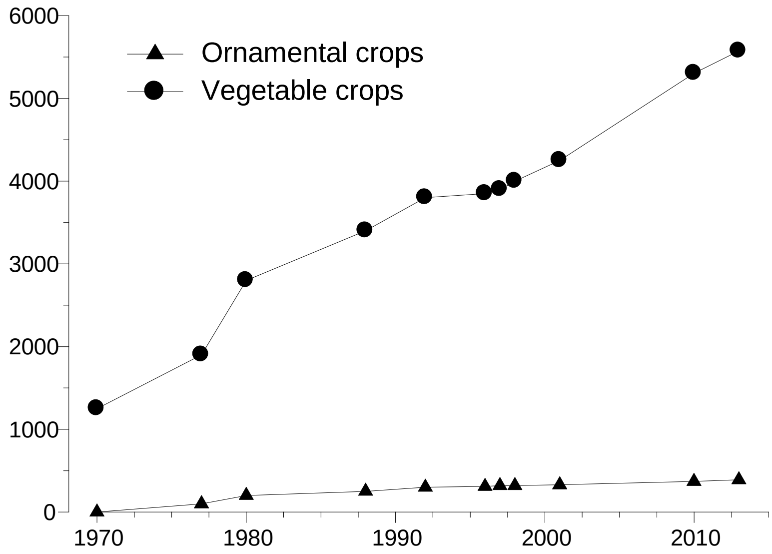

Figure 2.2. Evolution of greenhouse cultivated area for vegetables and ornamentals in Greece.

The most important vegetable crop species grown in greenhouses in Greece are tomato and cucumber, followed by strawberries and pepper in terms of both, total area and total production. The cultivated area and the total production for each vegetable species are given in Table 2.5. Most of greenhouse vegetable production is consumed within the country; only cucumber is exported to a large extend, particularly in central and north Europe.

Table 2.4. Area and production of vegetable crops in protected cultivation in 2005.

Crop species	Tall greenhouses										2nd crop		Low tunnels		Total (protected cultivation)	
	Heated greenhouses				Unheated greenhouses				Total (tall greenhouses)							
	Glasshouses		Plastic-covered greenhouses		Glasshouses		Plastic-covered greenhouses									
	area (ha)	prod. (ton)	area (ha)	prod. (ton)	area (ha)	prod. (ton)	area (ha)	prod. (ton)	area (ha)	prod. (ton)	area (ha)	prod. (ton)	area (ha)	prod. (ton)	area (ha)	prod. (ton)
Tomato	45.2	3,794	593.8	59,539	6.6	990	2,193.6	167,848	2,839.2	232,171	645.7	59,917	31.0	2,130	3,515.9	294,218
Cucumber	11.1	545	281.2	39,573			645.2	77,825	937.5	116,358	457.9	51,631	4.5	22	1,389.7	168,629
Zucchini	0.2	6	41.6	2,735			128.1	8,372	169.9	11,113	65.9	3,183	158.0	4,160	393.8	18,456
Eggplant	2.1	106	31.7	1,762			118.1	9,899	151.9	11,688	12.2	613	13.5	655	176.5	11,287
Pepper	0.5	52	145.8	10,703			430.7	33,798	577.0	44,653	84.7	5,079	6.5	230	668.2	49,962
Bean			75.7	2,056			114.8	2,879	190.5	4,965	134.7	3,072	7.0	105	334.0	8,142
Lettuce			11.8	277			51.4	1,384	63.2	1,661	226.8	5,214	3.0	65	293.0	6,940
Melon			1.2	58			23.2	1,295	24.4	1,353	78.0	4,455	1,314.0	42,020	1,416.4	47,828
Watermelon			1.0	80			27.0	1,380	28.0	1,460	60.0	3,000	6,220.5	331,660	6,308.5	336,120
Strawberry							351.2	13,140	351.2	13,140			115.5	4,792	466.7	17,932
Total	59.1		1,183.8		6.6		4,083.3		5,323.3		1,765.9		7,873.5		14,962.7	

Table 2.5. Area and production of vegetable crops in protected cultivation in 2012.

Crop species	Tall greenhouses										2nd crop		Low tunnels		Total (protected cultivation)	
	Heated greenhouses				Unheated greenhouses				Total (tall greenhouses)							
	Glasshouses		Plasticcovered greenhouses		Glasshouses		Plastic-covered greenhouses									
	area (ha)	prod. (ton)	area (ha)	prod. (ton)	area (ha)	prod. (ton)	area (ha)	prod. (ton)	area (ha)	prod. (ton)	area (ha)	prod. (ton)	area (ha)	prod. (ton)	area (ha)	prod. (ton)
Tomato	62.2	11,203	425.2	41,165	23.9	2,510	1,393.0	164,161	1,904.3	219,039	710.9	71,059	11.7	340	2,626.9	290,437
Cucumber	11.5	1,405	188.3	28,578	25.4	5,280	895.5	93,178	1,120.6	128,441	317.9	38,582	2.5	55	1,441.0	167,077
Zucchini	0.9	41	15.0	729	3.0	240	57.4	2,137	76.3	3,147	31.8	866	119.0	3,290	227.1	7,303
Eggplant	0.7	56	16.0	968	3.0	220	155.8	16,884	175.6	18,128	12.3	754	0.0	0	187.8	18,881
Pepper	11.9	1,570	78.9	4,935	8.3	716	626.9	71,132	725.9	78,353	52.8	3,411	0.0	0	778.7	81,764
Bean	2.0	50	62.2	1,978	7.5	260	104.4	2,167	176.1	4,455	125.9	3,378	0.0	0	302.0	7,833
Lettuce	1.8	63	22.4	634	3.0	120	115.8	2,489	143.0	3,306	237.8	4,704	0.0	0	380.8	8,010
Melon	0.1	0	2.1	85	1.0	20	2.0	100	5.2	205	118.0	8,400	746.3	29,122	869.5	37,727
Watermelon	0.2	0	1.6	96	6.0	420	14.5	620	22.3	1,136	685.0	39,150	1,536.3	84,620	2,243.6	124,906

Strawberry	0.0	0	0.0	0	0.0	0	1,163.0	43,927	1,163.0	43,927	2.0	60	15.0	303	1,180.0	44,290
Miscellaneous	2.0	0	16.9	1,135	1.0	15	42.1	772	62.1	1,922	50.9	1,005	2.5	30	115.5	2,957
Total	93.3	14,388	828.6	80,301	82.1	9,801	4,570.4	397,568	5,574.3	502,058	2345.2	171,368	2,433.3	117,760	10,352.8	791,185

Table 2.6. Regional distribution of the area (ha) cultivated with vegetables under cover* in Greece (Greek Ministry of Agriculture, 2014).

Administrative region	Tomato	Cucumber	Zucchini	Eggplant	Pepper	Green bean	Lettuce	Melon	Watermelon	Total (ha)	Total (%)
Eastern Macedonia & Thrace	47.5	15.0	0.9	4.3	39.4	4.1	7.3	100.2	300.1	518.8	4.7
Central Macedonia	292.7	161.2	70.8	55.1	243.7	117.7	256.8	152.6	461.1	1,811.6	16.3
Western Macedonia	3.0	2.6	0.3	1.8	11.1	0.4	1.6	0.0	0.0	20.8	0.2
Epirus	282.2	107.6	12.4	11.2	17.4	15.6	33.7	4.6	23.2	507.8	4.6
Thessaly	74.1	8.7	2.6	3.6	12.5	10.1	11.3	92.8	209.0	424.7	3.8
Ionian Islands	13.8	2.1	1.4	0.9	1.1	0.3	0.7	2.0	15.0	37.2	0.3
Western Greece	154.0	72.0	350.0	12.0	36.2	124.3	180.0	215.4	984.4	2,128.3	19.1
Central Greece	30.0	12.8	10.5	0.6	1.7	3.3	2.0	2.7	1.6	65.1	0.6
Attica	113.6	59.1	15.9	7.5	3.7	8.8	51.2	0.4	0.0	260.1	2.3
Peloponnese	473.2	213.2	57.9	75.8	87.3	68.2	15.5	9.3	607.5	1,607.9	14.4
North Aegean Islands	33.5	9.6	7.0	1.6	1.4	3.6	5.9	8.5	163.7	234.8	2.1
South Aegean Islands	60.9	81.2	9.8	9.0	9.6	2.4	6.3	1.9	8.4	189.5	1.7
Crete	1,485.9	842.9	27.5	173.1	623.9	46.9	1.6	95.9	40.9	3,338.6	30.0
Total (ha)	3,064.3	1,588.0	566.9	356.6	1,089.0	405.6	573.8	686.3	2,814.9	11,145.3	100.0
Total (%)	27.5	14.2	5.1	3.2	9.8	3.6	5.1	6.2	25.3	100	

* The area under cover includes both low tunnels and tall greenhouses.

Table 2.7. Regional distribution of the total vegetable production (tons) under cover* in Greece (Greek Ministry of Agriculture, 2014).

Administrative region	Tomato	Cucumber	Zucchini	Eggplant	Pepper	Green bean	Lettuce	Melon	Watermelon	Total (ha)	Total (%)
Eastern Macedonia & Thrace	9,105	735	34	78	2,107	61	112	6	23	12,261	1.6
Central Macedonia	25,191	12,291	942	2,018	14,760	2,485	2,819	37	1,027	61,571	8.0
Western Macedonia	154	50	12	56	175	15	26	0	0	487	0.1
Epirus	26,879	15,651	449	541	492	381	473	37	1,279	46,183	6.0
Thessaly	3,315	945	63	99	483	117	65	2,554	10,589	18,231	2.4
Ionian Islands	167	25	1	2	2	0	0	0	0	197	0.0
Western Greece	10,880	7,120	15,540	502	660	3,054	889	2,900	19,500	61,045	8.0
Central Greece	3,093	667	210	8	20	37	4	135	0	4,173	0.5
Attica	1,000	320	60	65	0	27	3,070	0	0	4,543	0.6
Peloponnese	33,383	41,843	1,223	2,718	6,249	1,838	255	224	40,138	127,871	16.7
North Aegean Islands	2,320	772	220	64	56	26	81	350	15,880	19,769	2.6
South Aegean Islands	1,940	2,004	56	148	245	86	11	0	64	4,553	0.6
Crete	227,600	83,360	1,309	16,010	67,375	1,748	15	6,436	2,442	406,295	53.0
Total (ha)	345,027	165,782	20,120	22,310	92,624	9,876	7,820	12,679	90,942	767,180	100.0
Total (%)	45.0	21.6	2.6	2.9	12.1	1.3	1.0	1.7	11.9	100	100.0

* The area under cover includes both low tunnels and tall greenhouses.

Table 2.8. Regional distribution of the area (ha) cultivated with vegetables in tall greenhouses in Greece (Greek Ministry of Agriculture, 2012).

Administrative region	Tomato	Cucumber	Zucchini	Eggplant	Pepper	Green bean	Lettuce	Melon	Watermelon	Strawberry	Other	Total (ha)	Total (%)
Eastern Macedonia & Thrace	43.4	9.6	0.8	4.4	18.4	10.3	5.0	0.0	1.6	0.0	3.6	97.1	1.7
Central Macedonia	215.8	102.7	19.3	14.7	31.7	24.1	41.0	0.0	0.0	7.4	44.9	501.6	9.0
Western Macedonia	2.3	1.1	0.3	0.4	1.2	1.0	0.0	0.0	0.0	0.0	0.7	7.0	0.1
Epirus	144.0	54.0	5.0	3.9	15.5	2.8	30.6	0.0	0.0	0.0	0.0	255.8	4.6
Thessaly	39.0	14.5	5.7	0.7	2.0	4.5	7.8	0.0	0.2	0.0	0.0	74.4	1.3
Ionian Islands	7.0	1.1	0.2	0.3	0.2	0.2	0.2	0.0	0.0	0.0	0.0	9.2	0.2
Western Greece	141.0	53.5	21.0	8.7	13.5	92.7	43.0	2.0	14.5	1151.8	1.0	1542.7	27.7
Central Greece	21.1	5.2	0.1	0.4	0.5	0.6	0.4	0.0	0.0	1.0	2.2	31.4	0.6
Attica	101.0	53.6	1.9	3.2	0.0	0.1	9.0	0.0	0.0	0.0	5.7	174.5	3.1
Peloponnese	95.0	83.0	7.0	5.5	32.5	33.0	3.0	3.1	6.0	2.5	4.0	274.6	4.9
North Aegean Islands	27.2	6.0	0.5	1.4	1.1	2.1	3.0	0.1	0.0	0.3	0.0	41.6	0.7
South Aegean Islands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crete	1067.4	736.5	14.5	132.0	609.3	4.8	0.0	0.0	0.0	0.0	0.0	2564.5	46.0
Total (ha)	1904.3	1120.6	76.3	175.6	725.9	176.1	143.0	5.2	22.3	1163.0	62.1	5574.3	100.0
Total (%)	34.2	20.1	1.4	3.1	13.0	3.2	2.6	0.1	0.4	20.9	1.1	100	100.0

2.4.4. Geographical distribution of protected cultivation in Greece

The regional distribution of protected vegetable area and production in Greece, including greenhouses and low tunnels, is shown indicatively for 2014 in Tables 2.6 and 2.7. Crete is the leading region of Greece in protected cultivation, in terms of both cultivated area and total production, followed by Western Greece, Peloponnese, and Central Macedonia. The total area of protected cultivation in Crete amounted to 30% in 2014 but the production harvested from that area was higher than half (53%) of the total vegetable production obtained from protected cultivation. The much higher quote of production than that of the area cultivated under cover in Crete, with reference to the total figures at domestic level, points to a much higher productivity in this region. The higher productivity of Cretan protected cultivation results mainly from the fact that this comprises mainly greenhouses, while in other regions and especially in Western Greece and Peloponnese, an appreciable amount of protected cultivation is covered by low tunnels. Indeed, when low tunnels are not included, almost half of the domestic greenhouse area (i.e. 46% in 2012 as shown in Table 2.8) is located on the island of Crete with Ierapetra being the largest area, followed by Messara plain. Western Greece, with the regional units of Ilia and Achaia as main centers of greenhouse strawberry production, holds another quarter (27.8% in 2012 as shown in Table 2.8) of the Greek greenhouse area. An additional 10% of greenhouse area is located in Central Macedonia and especially around the plain area of Giannitsa, which supplies mainly the large consumption center of Thessaloniki. Peloponnese, which accounts for another 5%, is also considered an important greenhouse production center with the province of Trifilia in Messenia being the leading location. Finally, another 4.6% of the Greek greenhouse area is located in Epirus, with main greenhouse center being the regional unit of Preveza. The remainder greenhouse area is scattered all over the country. It is surprising that according to the statistics of the Greek Ministry of Rural Development and Food for 2012, no greenhouses are located in the Southern Aegean Islands. Actually, this is not true, since it is well-known that this region also accommodates greenhouses (e.g. Rhodos). Also, the 5% of the total domestic greenhouse area that is allocated to Peloponnese in 2012 seems underestimated and may be due to shortcomings in the statistics of the Ministry of Rural Development and Food.

2.4.5. Types of greenhouses

Today, most greenhouses used for vegetable production in Greece are standardized constructions. According to data from the Greek Ministry of Rural Development and Food for 2012 about 82% of the Greek greenhouses follow national and EU specifications and only 18% are old-type simple constructions (Table 2.9). Currently, the greenhouse constructions are dominated by the use of plastic as covering material, particularly those used for vegetable production, while glass is used only to a limited extent. In particular, nearly 98% of the total greenhouse area in Greece is plastic-covered and only 2% are glasshouses. The covering material in most of plasticcovered greenhouses used for vegetable production is low-density polyethylene film. Regarding the structures, a total of 67.5% of the greenhouses used for vegetable production consist of metallic structures (Table 2.9). A significant proportion of the greenhouse area used for vegetables is occupied by high tunnels.

Table 2.9. Types of greenhouses in Greece, allocated according to the type, covering material and the application of heating (Greek Ministry of Rural Development and Food, 2012).

Type	Standardized constructions					Simple constructions			
Cover	Glass	Plastic				Plastic			
Structure		Metallic		Wood	Mixed	Metallic		Wood	Mixed
Roof		Round arched	Saddle	Saddle	Saddle	Round arched	Saddle	Saddle	Saddle
Area (ha)	114.2	1969.3	1777.6	615.9	364.3	237.1	215.5	397.3	210.8
Area (%)	1.9	33.4	30.1	10.4	6.2	4.0	3.7	6.7	3.6

2.4.6. Equipment of vegetable greenhouses

All greenhouse cultivation systems, regardless of geographic location, consist of fundamental climate control components, and depending on their design and complexity, they can provide a greater or lesser amount of climate control, and subsequent plant growth and productivity. However, although greenhouses in north Europe need mainly heating and greenhouses in south Europe need mainly cooling, in Greece there is a need for both cooling and heating. Temperature is the most important variable of the greenhouse climate that can and has to be controlled.

The majority of plants grown in greenhouses in Greece are warm-season species and are adapted to average temperatures in the range 17-27 °C, with approximate lower and upper temperature limits of 10°C and 35°C. If the mean minimum of the outside temperature is below 10 °C the greenhouses used for the production of warm-season vegetables requires heating, particularly at night. When the mean maximum of the outside temperature is lower than 27°C, only ventilation is normally needed to prevent excessive levels of inside temperatures during the day. However, if the mean maximum of the outside temperature exceeds 27-28 °C, then active cooling may be necessary. The maximum greenhouse temperature should not exceed 30-35 °C for prolonged periods. However, the daytime temperatures in Greece are too high for ventilation to provide sufficient cooling during the summer. The attainment of suitable temperatures then requires cooling.

The fuel cost for greenhouse heating is relatively high in Greece. Therefore, most vegetable greenhouses are not heated in Greece. Up to date, most of Greek greenhouses used for vegetable production rely on the exploitation of the warm and sunny weather conditions, which enable out of season production of vegetables with minimal or –more frequently- without any fuel consumption. However, heating in the winter is necessary to attain proper temperature levels, which are a prerequisite for high yield and good quality products. As a result, low yields and poor quality suppress the grower income per m^2.

As shown in Table 2.5, only a minor percentage (26.7%) of the greenhouse area used for vegetable production is heated in Greece. However, 53.16% of the greenhouses covered by glass and used for vegetables are heated. In contrast, only 15.35 % of the plastic greenhouses are heated. In the greenhouses used for vegetable production, the installation of central heating systems is not usual. Instead, various forced-air heaters and stoves are used.

2.4.7. Level of automation

The level of automation in the greenhouses used for vegetable production in Greece is unsatisfactory. In an appreciable part of them, even ventilation is still manually performed. When better greenhouse constructions are used, these are mostly accompanied by a partial automation for temperature regulation and fertigation application (based on preset irrigation scheduling). Usually, the regulation of the inside temperature is based on temperature sensors and set-point temperatures and is performed by means of automated switching of either the heating system in the winter or side and roof ventilators or fan-and-pad systems, when the inside temperature rises to undesired levels. Computer controlled, integrated automation systems based additionally on sensor-based measurements of solar radiation and relative humidity, which include also shading and fog systems, are only exceptionally used in greenhouse vegetable production, despite the serious problems arising from the very high temperatures prevailing in the summer. Nevertheless, statistical data about the use of computer-controlled automation systems for climate and fertigation control in the Greek greenhouses are not available.

2.4.8. Soilless *vs*. soil-based production of greenhouse vegetables

In contrast to northern Europe, where the greenhouses sector relies mainly on soilless culture, most greenhouse crops in Greece are grown in the soil. Currently, soilless culture in Greece occupies approximately 180 ha, which corresponds to nearly 3.3% of the total greenhouse area. These data are based on information collected by the contributors of this study. Official data regarding the greenhouse area covered by soilless cultivations in greenhouses have not been recorded either by the Greek Ministry of Rural Development and Food or by the Hellenic Statistical Authority.

When low-tech greenhouses consisting of simple constructions are used for out-ofseason vegetable production, the general strategy of the local growers is to avoid even a small increase in the installation and operation costs that is required to introduce hydroponics. In such greenhouses, soilless culture becomes an option only when the problems originating from the soil become critical. This seems to be the main reason for the limited application of soilless vegetable production in Greece to date. However, the phase-out of methyl bromide for soil fumigation in compliance with the Montreal Protocol increasingly forces greenhouse growers in Greece to switch to soilless culture. Thus, soilless culture is becoming increasingly important in protected cultivation not only in modern, fully equipped glasshouses, but also in the simple greenhouse constructions used in areas with mild winter climate. Although soilless culture seems currently the safest and most effective alternative to the use of methyl bromide for soil fumigation, soil solarization and grafting are also important tools for the preventive control of soil-borne diseases in the Greek greenhouses.

Mineral wool is currently the most widely used substrate in vegetable production in Greece. Besides mineral wool, coir dust and two locally produced porous materials, particularly perlite and pumice, are used for soilless cultivation of vegetables in Greece. All these substrates are virtually free of pathogens and can easily be disinfested between growth cycles in order to provide a disease-free start of the new crop.

In the last five years, some high-tech hydroponic glasshouses were constructed in Northern Greece, particular in Macedonia and Thrace (e.g. AGRITEX, http://www.agritex.gr/, WONDERPLANT, http://www.wonderplant.gr/, Thermokipia Thrakis). The mean size of each of these greenhouse units amounts to about 10 ha. In most of these greenhouses, installations for co-production of electricity through consumption of natural gas are used, which enable heating through the hot water produced in this process, thereby minimizing the energy cost. Production in these glasshouses takes place in modern soilless cultivation systems using rockwool slabs as growing media.

Soilless culture is capable of improving yield, while providing more efficient tools for managing produce quality, due to better control of the conditions prevailing in the root environment. On the other hand, the limited volume of the root zone in soillessgrown crops appreciably restricts their buffering capacity with respect to nutrient and water supply to the plants. Consequently, the optimization of plant nutrition and irrigation in soilless-grown greenhouse crops is more beneficial but at the same time relies much more on scientific knowledge and skilful cultural operations. Therefore, the modern technologies associated with soilless cultivation will be outlined to some detail in this study (Section 5.4), although this is not the predominant cultivation system in the Greek greenhouses.

2.4.9. Investment cost of a greenhouse in Greece

The investment cost of a standard greenhouse in Greece may vary between 30-60 € m^{-2}. The lowest level of this range refers to plastic-covered greenhouses with a limited level of equipment and no automation systems. The highest cost range corresponds to plastic-covered greenhouses with a metallic frame and a medium to high level of equipment. Even higher costs approaching or even exceeding 100 € m^{-2} are incurred for glasshouses with full equipment like those used in the Netherlands and other north European countries. An analysis of the cost needed to establish a commercial greenhouse is provided in the indicative Business Plan that is annexed to this study.

2.4.10. Production cost in a Greek vegetable greenhouse

The production cost in a Greek greenhouse can vary depending on the vegetable species, the season, the production system (e.g. heating or not, soil or soilless cultivation, energy and fertilizer input, etc.) and the grower. Furthermore, the production cost per mass (kg) of produce depends strongly not only on the expenses per cultivated area but also on the obtained marketable yield per area unit. Thus, costs incurred by some cultural practices, which have a strongly positive impact on yield and/or quality, may reduce rather than increase the production cost in terms of € kg^{-1}. Generally, the production cost for most fruit vegetables in Greek greenhouses may roughly range between 0.30 and 0.65 € kg^{-1}, depending on the aforementioned factors. An indicative cost analysis for greenhouse production in Greece is provided for tomato in Table 3.2 .

2.4.11. Income of greenhouse growers

The anticipated income per m^2 of cultivated greenhouse area varies strongly, depending on the situation prevailing in the local and the international market each year, the cultivated plant species, the size of the enterprise, the quality of the greenhouse constructions, and the available equipment. Of these factors, the growers can modify only those affecting the cost per cultivated area, the total yield, and the fruit quality. The average yield achieved in Greek greenhouses is relatively low (about 12 kg m^{-2} for tomato) and is lagging behind the one achieved in modern heated greenhouses in North Europe countries (i.e. 45 kg/m^2 for tomato in the Netherlands). Low production per unit of cultivated area in Greece is based on the fact that most of Greek greenhouses are not technologically advanced and have limited control over internal microclimate. In addition, the level of knowhow concerning nutrition and crop protection is low too. Last, due to inefficiencies in adjusting the internal microclimate and cultivation techniques, the cultivating period in many Greek greenhouses is relatively short. As a result, low yields are obtained by a major part of greenhouse growers, and thus also the net income is accordingly low. Nevertheless, well equipped modern greenhouses report up to 3-4 and even 5 times higher yields than the average levels shown in the statistics of the Ministry of Rural Development and Food. The estimated mean grower income per m^2 for vegetable production in greenhouses is shown indicatively for a greenhouse tomato crop in Table 3.2.

3. Greenhouse tomato as an example of greenhouse vegetable production

Tomato is the most important greenhouse crop in Greece. Over 50% of the total greenhouse area is used for fresh tomato production. As shown in Figure 3.1, the total area of greenhouse-grown tomato in Greece fluctuated from 2,520 ha to 3,060 ha with a mean level of around 2,778 ha during the last years (from 2007 to 2014). During the same time span, the total tomato production obtained from the Greek greenhouses fluctuated from 135,000 to 358,000 tons with a mean production level of around 258,375 tons (Fig. 3.1). These figures render an average yield of 93 tons ha⁻

[1]. This value is far below the mean production recorded in the Netherlands, which amounted to 458 tons ha^{-1} in 2003 (Costa and Heuvelink, 2005) and 474 tons ha^{-1} in 2012 (Olympios, 2015). A similar production level was recorded by FAOSTAT also in Belgium (464 tons ha^{-1} in 2012 according to Olympios, 2015).

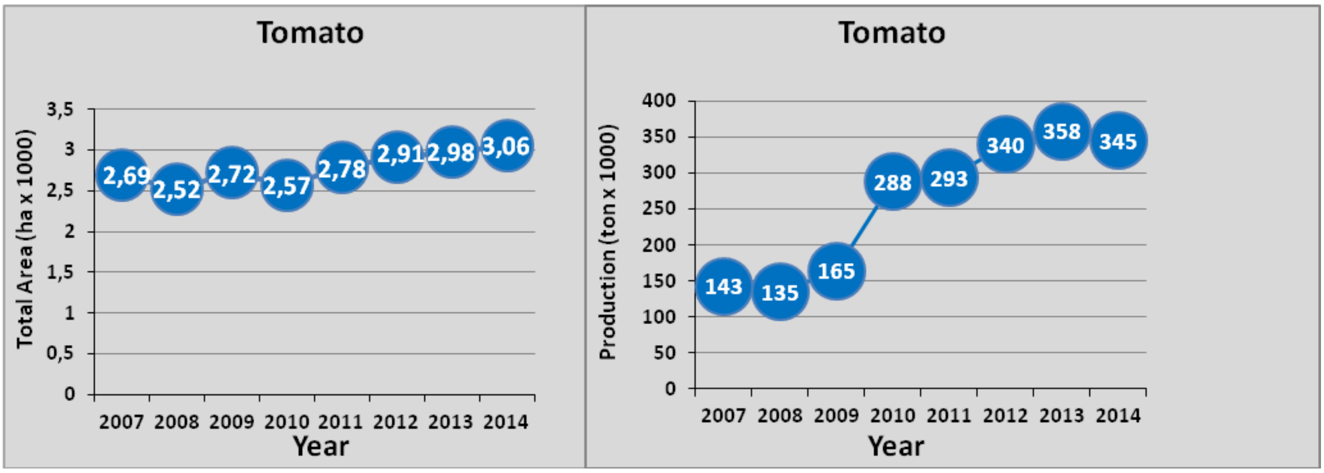

Figure 3.1. Total area (A) and total production (B) of fresh tomato cultivated in greenhouses in Greece during the years 2007-2014.

The allocation of the total greenhouse area cultivated with tomato into the 13 Regions of Greece and the corresponding production in each region are shown indicatively for 2014 in Table 3.1. These data indicate that almost half of the greenhouse tomato area is located in Crete (48.5%), followed by Peloponnese with 15.4%. These regions are most suitable for greenhouse tomato production because they are characterized by mild winter climatic conditions. Central Macedonia, ranks in the third position, because it covers the market needs of Thessaloniki for fresh tomato, although the climatic conditions are less favorable than in many other regions of southern Greece. Despite the unfavorable weather conditions in terms of winter temperatures, Central Macedonia as well as eastern Macedonia and Thrace accommodate the most modern tomato greenhouses that were founded in the last 8 years, because of the availability of natural gas and geothermal water which reduce heating costs.

Table 3.1. Fresh tomato cultivated area and production in Greek greenhouses allocated into the 13 regions of the country in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area (ha)	(%)	Total production (ton)	Mean production (ton/ha)
Eastern Macedonia & Thrace	48	1.6	9,105	191.68

Central Macedonia	293	9.6	25,191	86.07
Western Macedonia	3	0.1	154	51.16
Epirus	282	9.2	26,879	95.25
Thessaly	74	2.4	3,315	44.74
Ionian Islands	14	0.5	167	12.10
Western Greece	154	5.0	10,880	70.65
Central Greece	30	1.0	3,093	103.23
Attica	114	3.7	1,000	8.80
Peloponnese	473	15.4	33,383	70.55
North Aegean Islands	34	1.1	2,320	69.25
South Aegean Islands	61	2.0	1,940	31.88
	1,486	48.5		
Total	**3,064**	**100**		
Crete			227,600	153.17
			345,027	112.59

The prices of fresh tomato at the Central Fresh Fruit and Vegetable Wholesale Market (CFFVWM) of Thessaloniki in the next two years (2013 and 2014) were higher than 0.69 € kg^{-1}, as indicated by the monthly average prices shown in Figure 3.2. In particular, yearly average prices of 0.81 € kg^{-1} and 0.80 € kg^{-1} were recorded in 2013 and 2014, respectively. The higher prices recorded in the CFFVWM of Thessaloniki in 2013 and 2014 may reflect differences from market to market due mainly to commensurate differences in transportation cost. However, they partly indicate also a tendency towards higher prices for fresh-market tomatoes in the last years, as reported also by individual growers. On the other hand, the mean prices shown in Figure 3.2 do not differentiate between out of season tomato produced in greenhouses, which achieves a premium price, and field tomato produced in the warm season of the year (mainly from July to September), which is sold at lower prices, thereby reducing the average yearly price. Furthermore, the mean prices shown in Figure 3.2 were estimated by considering also tomatoes from low-tech greenhouses which render a high percentage of Class II produce. Tomatoes from heated greenhouses (medium to high technological standard) are of superior quality and achieve higher prices than the average level shown in Figure 3.2. Thus, the viability of greenhouse tomato production and the anticipated net income for growers should be estimated by considering higher wholesale prices per kg than those shown in Figure 3.2. Nevertheless, due to market uncertainty which cannot be influenced by tomato producers, the focus should be concentrated on the mean production per area unit, which can be increased by technological improvements, while decreasing or at least not increasing the production cost per kilogram of fruit.

While greenhouse tomato cropping can generate high cash receipts, it requires a large investment. For a heated tomato crop grown in a hydroponic greenhouse in Greece, which follows a long-cycle cultivation schedule with a yield goal of 400 metric ton ha^{-1}, production costs for heating, machinery, labor, seedlings, fertilizers, chemicals, and other expenditures are estimated to total €258,700 per hectare (see business plan for a hydroponic greenhouse tomato crop). A price of more than €0.65 per kilogram is required to break even. Thus, the grower income in medium- to high-tech greenhouses is proportional to the increase of the mean tomato price to levels above 0.65 € kg^{-1}, assuming the yield goal (400 metric ton ha^{-1}) is achieved. In the low-tech greenhouses, the production cost per kg of fruit may be even higher due to the low yields which decreases the denominator in the fraction (total cost)/(total yield). However, in the nonheated low-tech greenhouses, the only feasible possibility to decrease the production cost per kg of marketable fruit is to increase the yield and quality (and thus the gross returns) by some improvements e.g. in plant protection (screen nets, etc.), fertilization, irrigation, etc., because the total expenditures are already kept at a minimum.

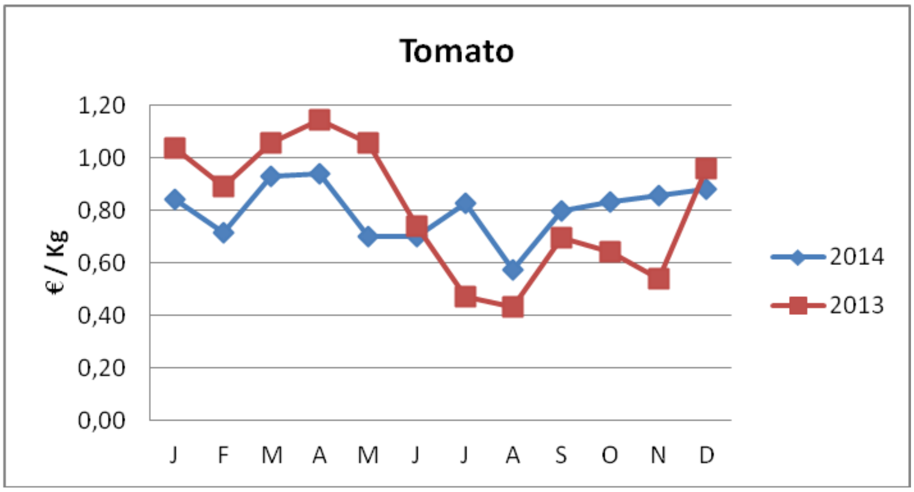

Figure 3.2. Mean monthly prices for fresh-market tomatoes during the years 2013 and 2014 at the Thessaloniki Central Fresh Fruit and Vegetable Wholesale Market.

The much lower mean tomato production per unit of cultivated area in the Greek greenhouses (93 tons ha^{-1}) in comparison with that achieved in Dutch and Belgian greenhouses reflects commensurate differences in the technological level. Indeed, as shown in Table 2.5, most Greek greenhouses used for vegetable production, including tomato, are unheated, while in most of the heated greenhouses, the temperature is maintained at sub-optimal levels to minimize the fuel cost. Nevertheless, the differences in production per unit of cultivated area do not represent commensurate differences in net income, because the production cost in the unheated and the minimally heated Greek greenhouses is much lower. This is clearly demonstrated by the data presented in Table 3.2, which show production costs and net incomes according to three different production strategies.

Table 3.2. Production costs and net incomes from greenhouse tomato crops according to three different production strategies.

COSTS/RETURNS	Soil-based crop in unheated greenhouse	Hydroponic crop in plastic-covered greenhouse	Hydroponic crop in high-tech glasshouse
Seedlings (€ ha^{-1})	8,100	17,500	17,500
Fertilization (€ ha^{-1})	12,000	22,750	22,750
Heating (€ ha^{-1})	0	64,000	82,000
Plant protection & bumblebees (€ ha^{-1})	6,200	4,600	4,600
Labor (€ ha^{-1})	34,000	64,000	64,000
Package & transport (€ ha^{-1})	7,200	32,000	38,400
Soil preparation	2,000	0	0
Substrate and other consumables (€ ha^{-1})	900	8,200	24,000
Electricity (€ ha^{-1})	800	2,750	3,600
Capital depreciation (€ ha^{-1})	9,000	36,000	84,000
Other operating cost (water, Internet, etc.) (€ ha^{-1})	600	2,100	2,100
Unpredictable costs (€ ha^{-1})	800	4,800	4,800
TOTAL PRODUCTION COST (€ ha^{-1})	**81,600**	**258,700**	**347,750**
Total marketable Produce (kg ha^{-1})	120,000	400,000	480,000
Mean product cost (€ kg^{-1})	0.68	0.65	0.72
Mean selling value (€ kg^{-1})	0.75	0.92	1.05
GROSS RETURNS (€ ha^{-1})	**90,000**	**368,000**	**504,000**
Net income (€ ha^{-1})	**8,400**	**109,300**	**156,250**
Payback (%)	4.67	15.18	9.30

The first strategy represents a soil-grown tomato crop in a low tech, unheated greenhouse. The second scenario represents a hydroponic tomato crop in a partially heated greenhouse with medium-level climate control. The third scenario represents a hydroponic tomato crop in a fully heated glass-covered greenhouse with high level climate control, similar to that applied in the Netherlands. The third scenario in Greece is represented by some Dutch-type modern glasshouses that have been recently established in Northern Greece (Macedonia and Thrace), such as AGRITEX (http://www.agritex.gr/) and WONDERPLANT (http://www.wonderplant.gr/). The data are based on information provided by growers and local agronomists. These data clearly indicate that the second scenario is the most attractive for Greece providing the highest payback, while the third scenario results in marginally positive economic results, which may readily turn into economic losses if the anticipated yield is not achieved due e.g. to an unexpected spread of a pathogen. It should be noted that the third scenario is currently economically viable in the modern glasshouses recently established in Northern Greece, but these enterprises, in addition to tomato, produce also electricity using natural gas and thus they can heat their greenhouses at no cost.

Table 3.3. Total amounts and values of Greek imports and exports of fresh tomato during the years 2000-2014.

	Imports			Exports			
Year	Quantity (tons)	price (€/kg)	Total value (million €)	Quantity (tons)	Share of production (%)	price €/kg	Total value million €
2000	4,491	0.88	3,948	2,808	0.39	0.54	1,517
2001	8,915	0.74	6,597	4,308	0.62	0.52	2,239
2002	14,825	0.82	12,180	6,719	0.98	0.31	2,095
2003	19,676	1.03	20,322	3,186		0.33	1,053
2004	20,042	0.86	17,252	2,928	0.43	0.41	1,194
2005	17,194	0.77	13,298	2,956	0.43	0.39	1,161
2006	21,156	0.70	14,844	3,524	0.52	0.35	1,243
2007	22,710	0.96	21,812	4,461	0.52	0.49	2,182
2008	17,417	1.01	17,554	4,886	0.61	0.47	2,283
2009	15,642	0.92	14,383	4,107	0.42	0.46	1,886
2010	17,329	0.97	16,813	8,876	0.90	0.50	4,428
2011	15,723	0.75	11,866	16,010	2.49	0.44	6,968
2012	15,879	0.78	12,362	16,758	2.60	0.48	7,987
2013	8,243	0.57	4,702	20,001	2.92	0.58	11,589
2014	9,202	0.55	6,466	39,074	7.10	0.43	16,850
Mean	15,230	0.82	14,095	9,373	1.50	0.45	4,312

The Greek imports and exports of tomato from 2000 to 2014 are shown in Table 3.3. These data show that the imports tend to decrease in the last years, while the exports tend to increase. As a result, the quantities of exported tomato were twice as high as those imported in 2013, while their ratio increased to about 4:1 in 2014. However, the import prices were higher than the export prices with the exception of 2013. The higher import prices that those of export are ascribed to the fact that Greece exports mainly to Southeastern European countries while importing from Belgium and the Netherlands. However, the current export prices also show that the quality of the tomato exported by Greek growers is currently not high enough to deserve premium prices. The factors that negatively influence the quality of greenhouse tomatoes in Greece and the required improvements in technology are outlined in the next.

Depending on their size, five major types of tomatoes can be distinguished (Costa and Heuvelink, 2005):

- Cherry and cocktail tomatoes. They are very popular in many countries due to their taste and flavor. Generally, they are sweeter, with a higher dry matter content than the other four types of tomato. The weight of cherry tomato ranges from 5 to 20 g and their diameter from 1.6 to 2.5 cm. Cocktail tomatoes are larger than cherry tomatoes. In the last years, cherry and cocktail tomatoes of different shapes (e.g. round, oval, long, etc.) and colors (e.g. yellow, golden, orange, purple) have been introduced to the cultivation. The yield obtained by cherry and cocktail tomato is about 50-60% of that provided by standard-round and beefsteak tomatoes. However, the price of cherry tomatoes in the market is typically twice to three times higher than that of standard-round and beefsteak tomatoes.

- Standard round tomatoes. This is the most common type of tomato, with a weigh ranging from 70 to 120 g and a diameter ranging from 4.7 to 6.7 cm. This type of tomato was traditionally not very popular in Greece but in the last years its popularity steadily increases.
- Beefsteak tomatoes. The tomatoes of this type are characterized by a large size (mean weight ranging from 180 to 250 g or even more) and contain five or more locules. Their shape varies from fully rounded to prolate. Most beefsteak tomatoes are red or pink. Beefsteak tomato is the preferable type of tomato fruit in Greece.
- Plum and baby plum tomatoes. They have a typical oval shape resembling cultivars used as processing tomatoes. The flesh is firm and less juicy in the center. They have high sugar content and are normally tasteful.
- Cluster tomatoes. The common characteristic of this tomato type is that the fruit is harvested and sold in groups attached to the truss (cluster). Their size ranges from that of cherry to that of beefsteak tomatoes. This type of tomato is becoming increasingly popular in Greece in the last years.

With respect to the crop requirements, tomato is a warm-season vegetable with a moderate demand in high temperatures (T). Although the plants can survive at as low temperatures as 1 ^{o}C for short time periods, the growth virtually ceases at temperatures below 9 ^{o}C. At temperatures lower than 14 ^{o}C, the root growth and functionality is strongly restricted. As a result, water and active nutrient uptake are restricted. Especially the uptake of phosphorus is minimized at T levels lower than 14 ^{o}C, thereby resulting in marked P deficiency symptoms. However, fruit setting is impaired already at temperatures lower than 16-17 ^{o}C, while at temperatures lower than 13 ^{o}C, fruit setting is severely restricted due mainly to impairment of pollen development and pollen fertility. According to Charles and Harris (1972), pollen formed at T<10 ^{o}C is incapable of germinating and thus entirely infertile. On the other hand, at higher temperatures than 31 ^{o}C, the pollen formation and fertility is also impaired. In addition to fruit setting, low temperatures (<16 ^{o}C) also restrict the fruit development, particularly the ripening process and the formation of lycopene and carotene pigments. These data clearly point to the need of maintaining temperature levels between 17 and 30 ^{o}C in greenhouses used for tomato production.

Maintaining higher relative humidity levels than 60% inside greenhouses used for tomato production is essential to avoid yield losses due to both excessive dryness of the stigma, which impairs pollen germination, and partial stomata closure, which restricts photosynthesis. In addition, low levels of relative humidity inside a tomato greenhouse increase the incidence of blossom-end rot, thereby restricting the percentage of marketable produce. On the other hand, high levels of relative humidity that exceed 80% promote infections by botrytis and other fungal and bacterial diseases, while even higher RH levels (>90%) restrict fruit setting due to aggregation of pollen grains.

Greenhouse tomato is always a transplanted vegetable in Greece. Most greenhouse tomato producers purchase seedlings from commercial nurseries. Most nurseries use modern equipment to automatically fill up trays with substrate and sow seeds which are raised in controlled environment chambers under optimal temperature and humidity conditions. The use of automation has reduced the cost of the seedlings to about 0.3 € when self-rooted and 0.7 € when grafted onto commercial rootstocks. Grafted seedlings are used in about 20% of the total greenhouse area cultivated with fresh tomato. Due to the much higher prices of the grafted seedlings in comparison with the self-rooted ones, many growers order two-stem seedlings, which are obtained by pinching the grafted scion right above the cotyledons, thereby halving the number of purchased seedlings. The most commonly used rootstocks for tomato grafting are Maxifort and He-man.

Greenhouse tomato in Greece may be transplanted any time during the year. However, the most common seasons for transplanting are the end of August up to the end of September, aiming at commencing harvest by November or December and terminating by mid or end of June (long-cycle growing season). The second most common time of transplanting greenhouse tomatoes in Greece is February, aiming at commencing harvest in April and terminating any time during the summer (short-cycle growing season). The ratio between the number of days from planting to crop termination and the total number of days per year (365) denotes the greenhouse occupation index (GOI). This index is about 0.94 in the Netherlands, while in longcycle tomato crops in Greece it is about 0.85-0.88 due to the summer break. However, in short-cycle tomato crops in Greece, the GOI is less than 0.5 in most cases.

Table 3.4. Recommended EC (dS m^{-1}), pH and nutrient concentrations (mmol L^{-1}) in nutrient solutions (NS) for soilless tomato crops grown under Mediterranean climatic conditions (Savvas et al., 2013). The initially applied NS is that used to moisten the substrate or introduced to water culture systems before planting.

Desired characteristics	Initially applied NS	Vegetative stage SSOS[1]	SSCS[2]	RE[3]	Reproductive stage SSOS	SSCS	RE
[K^+]	6.80	7.00	6.40		8.00	7.50	
[Ca^{2+}]	6.40	5.10	3.10	7.80	4.50	2.30	8.00
[Mg^{2+}]	3.00	2.40	1.50	3.40	2.10	1.10	3.40
[NH_4^+]	0.80	1.50	1.60	<0.60	1.20	1.40	<0.40
[SO_4^{2-}]	4.50	3.60	1.50	5.00	4.00	1.50	6.00
[NO_3^-]	15.50	14.30	12.40	18.00	12.40	11.00	17.20
[$H_2PO_4^-$]	1.40	1.50	1.30	1.00	1.50	1.20	1.00

[Fe]	20.0	15.00	15.00	25.00	15.00	15.00	25.00
[Mn]	12.00	10.00	10.00	8.00	10.00	10.00	8.00
[Zn]	6.00	5.00	4.00	7.00	5.00	4.00	7.00
[Cu]	0.80	0.80	0.80	0.80	0.70	0.70	0.80
[B]	40.00	35.00	20.00	50.00	30.00	20.00	50.00
[Mo]	0.50	0.50	0.50	-	0.50	0.50	-

EC 2.80 2.50 2.00 3.20 2.40 1.85 3.40

8- 6.7

7.50

pH 5.60

5.8-6.7

5.60 - 5. 5.60 - 8.20

[1]SSOS: solution supplied to open systems; [2]SSCS solution supplied to closed systems; [3]RE target concentrations in the root environment.

The long-cycle season is preferred in the warmest regions of the country, particularly in southern Greece (e.g. Peloponnese and Crete), while the short-cycle season is practiced by growers in central and northern Greece, who cannot afford the heating cost during the winter. In many cases, when the short cycle is applied, tomato is followed by a second, short-life vegetable crop in autumn, (e.g., lettuce, zucchini, or bean). This practice is strongly suggested in short-cycle tomato crops, because the cultivation of tomato for a period of just 5-6 months, of which only 3-4 months are productive, is economically not viable.

Tomato plants in Greek greenhouses are set out in double rows, although in some old-type, low-tech greenhouses planting in single rows may be applied. Plant density, i.e. the number of plants per unit of cultivated area, has a strong impact on both total yield and product quality. High plant density up to a leaf area index of 4 (Heuvelink and Dorais, 2005) improves light interception and can maximize yield. However, if the ventilation rate is low, fungal and bacterial diseases may occur (e.g. botrytis, foliar blights, leaf spots, etc.) which can become severe very quickly, requiring frequent application of pesticides. Plant density should be lower in long-than in short-cycle tomato crops. As a guideline, a plant density of 2.5 to 2.8 plants m^{-2} in long-cycle and 3 to 3.5 plants m^{-2} in short-cycle single-stem tomato crops is suggested for Greek greenhouses. When two-stem grafted tomato plants are used, the plant density is halved so as to render similar stem densities with single-stem crops.

With the phasing out of methyl bromide as a soil fumigant, soil solarization has become an important tool in integrated greenhouse tomato production and is widely adopted also by Greek farmers who grow tomato in the greenhouse soil. The effectiveness of soil solarization can be improved if it is combined with the use of grafted seedlings. Alternatively, an increasing number of growers switch over to hydroponic tomato cultivation to escape the need of soil fumigation. The most widely used hydroponic system for tomato production in Greece is the cultivation on rockwool slabs wrapped in polyethylene bags and supplied with nutrient solution through a drip irrigation system. Other substrates, which are locally produced, particularly perlite and pumice, are used for soilless tomato cropping as well. In addition, coir dust (composted mesocarp tissue or husk of the coconut fruit) placed in bags is also used in some greenhouses for tomato production. Credible data regarding the allocation of the total greenhouse area cultivated with tomato into these four substrates are not available. Cultivation of tomato in recirculating nutrient solution (NFT-system) has been only sporadically practiced in Greece.

In soilless culture, tomato can tolerate total salt concentrations of up to 2.5-2.9 dS m^{-1} in the root zone without yield losses. However, in most cases, growers maintain higher EC levels than 2.5-2.9 dS m^{-1} in the root zone of soilless-grown tomato in order to improve fruit quality in terms of sugar content, dry matter content and firmness. The increase of EC to higher values than 2.5-2.9 dS m^{-1} in order to improve fruit quality is economically beneficial despite the concomitant yield losses because of the relatively low rate of tomato yield decrease per unit of EC increase above 2.5-2.9 dS m^{-1}. Under Mediterranean conditions, EC values of up to 3.5 dS m^{-1} in the root zone are recommended for soilless tomato in order to achieve premium fruit quality. Nevertheless, the EC of the nutrient solution in the root zone of tomato has to be reduced to lower levels than 3 dS m^{-1} under hot summer conditions.

A crucial factor for tomato nutrition in soilless culture is the N:K ratio in the supplied nutrient solution. On a molar basis, the mean N:K uptake ratio ranges from 2.2 to 2.4 prior to setting of fruit in the first truss of tomato but decreases to about 1.3-1.5 as the fruit load increases. Another important characteristic of the nutrient solution supplied to tomatoes is the ammonium to total nitrogen (NH_4-N/total-N) ratio. Both growth and yield of tomato are enhanced when a small part of nitrogen (N) ranging from 5% to less than 15% of the total-N is supplied in form of ammonium. Tomato is tolerant to moderately high pH but susceptible to low pH levels in the root environment, due mainly to impairment of the Ca uptake. With respect to the macronutrient cations, the K requirements of tomato increase with increasing fruit load, while those of Ca decrease. However, the Ca levels in the supplied nutrient solutions should be maintained at relatively high levels during the reproductive phase of the crop to minimize the incidence of blossom-end rot. Recommended nutrient solution concentrations for tomato are given in Table 3.4.

Greenhouse tomato in Greece is trained into one or two stems by removing all lateral shoots. The standard practice is to leave only one stem per plant. Training into two stems per plant is usual only in grafted plants to reduce the cost entailed by grafting. The shoots are supported using string (plastic or polypropylene twine), which is attached to a horizontal wire stretched above the plant row. In particular, the string is wrapped around the shoot or attached to it using plastic clips and fixed onto the horizontal wire either by the slip knot, or by metal string bobbins, or by a notched spool with a hook. If tomato is trained to two stems per plant, each stem is tied and grown as a single plant, but the stems develop on opposite sides of the rows and supported according to the V system. The high-wire system, which entails lowering and trailing the defoliated lower part of the stems, so as to lie horizontally at a height of about 10-30 cm above the ground, while the upper part of the shoot with the leaves and the fruit trusses grows vertically. This practice is known as the "leaning and lowering" training system. The most appropriate developmental stage to commence leaning and lowering the stem is at flowering of the fourth cluster, when the stem is becoming more flexible and less gristly but strong enough to resist breakage.

Pruning in greenhouse tomato should normally include also removal of old leaves (de-leafing) at a rate that equals the rate of new leaf unfolding, so as to maintain a standard leaf area index of about 4. Most of assimilates supplied to the fruit of each cluster originate from the two or three leaves under that cluster. If leaves are removed too early, the growth and final size of the fruit are adversely affected, but removal of the leaves under the fruit truss once fruit is at the mature green stage will speed up the ripening process, improve air circulation and reduce incidence of diseases favored by high humidity, such as botrytis. Old leaves have limited access to light and thus they consume more carbon through respiration than they can provide through photosynthesis. Leaf pruning is also necessary to facilitate lowering and trailing the lower part of the stem according to the "leaning and lowering" system. However, de-leafing is still not a common practice in Greek tomato greenhouses, despite its advantages in terms of both, yield and fruit quality. As a rule, maintaining a constant leaf number of 15-18 per plant, corresponding to a LAI of about 4 is recommended for Greek conditions.

In addition to de-leafing, fruit thinning has to be applied in medium- to large-sized tomato cultivars, so as to maintain a standard number of fruit per cluster and improve fruit quality. Although fruit thinning entails some additional labor cost, the benefits obtained due to increased fruit size and uniformity and removal of undersized and misshapen fruit, which increase considerably the percentage of fruit graded Class I, fully justifies this practice. In beefsteak tomatoes, which constitute the most common type of tomato grown in Greek greenhouses, the common practice is to prune the first three trusses to three tomatoes per truss and subsequently to four tomatoes per truss. If fruit setting in some trusses is poor, then, five fruit can be left in some trusses to balance the total number of fruit left on the plant. An empirical rule commonly applied in beefsteak tomato cultivars is to leave no more than 18 tomato fruit of different developmental stages at any time on the plant. An additional cultural practice applied in greenhouse tomato is to provide support to the basal part of the clusters by fixing truss braces, so as to prevent kinking due to the heavy fruit load. The first 8-10 trusses are more susceptible to kinking. The truss braces should be fixed to the base of the trusses before the fruit starts to enlarge.

An additional pruning practice applied in greenhouse tomato is to remove the growing top of the plants 5-8 weeks before the planned crop termination in order to avoid waste of assimilates to fruit that will be never harvested.

In the Greek greenhouses used for tomato production, fruit setting is facilitated either by the application of growth regulators, mostly β-naphthoxy-acetic acid (β-NOA) and 4-chlorophenoxyacetic acid (4-CPA), or by bumblebees. The plant growth regulators are applied mainly in unheated greenhouses during the cool season of the year to induce parthenocarpic fruit setting because the too low temperatures prevailing during most time of the day do not allow for normal pollen development and germination. The too high ambient temperatures in the summer also suppress pollen fecundity. Therefore, β-NOA is applied also in summer greenhouse crops of tomato in Greece, if the excessive heat is not effectively controlled. However, the quality of seedless parthenocarpic tomatoes is poor, and thus they are sold at relatively low prices in the local market, while they are not accepted for export. Commercial use of PGRs is subject to legislative restrictions set by the European Union (91/414/EEC). Therefore, in the last years, many growers of greenhouse tomato switch to the use of bumblebees as a means to facilitate fruit setting. Bumblebees are very fast, as they can visit 8–20 flowers per minute, and very efficient, as they can visit 400 flowers in each trip and, therefore, they are very effective pollinators. Nevertheless, bumble bees can improve fruit setting only by transferring pollen from the anthers to the stigma, thereby facilitating pollination. In contrast to open-field tomato crops, greenhouse crops need assistance for successful pollination due to limited air movement, high air humidity, and absence of natural insect activity inside the greenhouse. However, if the inside temperature is a limiting factor for sufficient pollen production and germination, facilitating pollination through bumblebees can have only a limited impact on fruit setting. Therefore, the use of bumblebees has been adopted mainly in heated greenhouses. A further expansion in the use of bumblebees aimed at improving fruit setting in greenhouse tomato crops is strongly recommended to improve the fruit quality and thus the produce value in Greece. However, introduction of bumblebees in greenhouse tomato crops has to be accompanied by commensurate improvements in climate control and especially in temperature regulation to effectively improve fruit setting and overall fruit quality. The bumblebees are introduced in the greenhouses in hives when the flowers are open. A standard hive contains 50–60 workers and one queen. Commonly five hives with bumblebees per hectare are needed to effectively pollinate tomatoes. Each new hive has an effective lifetime of about 10-12 weeks.

Tomato is picked either as individual fruit (sometimes without the green calyx, especially if intended for export), or by abscising the whole truss from the stem using scissors, which is marketed as “cluster tomatoes”. Fruits should be handled carefully to avoid damage, especially bruising. Tomatoes are harvested at various stages of ripeness and the storage conditions employed differ with each stage. In general, pre-cooling is required only if the fruit temperature exceeds 26-27°C and ripening is to be delayed. Although fully ripe tomatoes may be held at 2-5°C for a few days prior to consumption, fruit that are mature green or at the turning or breaking stage should not be subjected to temperatures lower than 12°C as chilling injury may occur, with adverse consequence for subsequent ripening and quality. Storage of fully ripe tomatoes at 2-5°C for more than 3-4 days results in color loss and softening, while the flesh becomes less aromatic, less sweet and more acidic than that of corresponding fruit stored for the same time length at 20°C.

Color is a major quality characteristic in virtually all fruits and vegetables and uniformity of color within tomatoes is a principal requirement of the E.U. quality standards for this crop. All fruit within a box must be at the same stage of ripeness during marketing. A tolerance level of 10% (by number or weight) not satisfying minimum requirements is permitted in each lot; this does not cover products affected by rotting or other deterioration making them unsuitable for human consumption.

4. Lettuce as an example of an open-field vegetable crop

Lettuce (*Lactuca sativa* L.) is subdivided in five subspecies, according to the morphology of the leaves and the formation of heads:

(1) Cos or Romaine lettuce (*L. sativa* var. *longifolia*, syn. *L. sativa* var. *romana*) is the most common type of lettuce in Greece and is characterized by the upright long leaves, usually of dark green colour, which form a more or less dense, oblong head.

(2) Butterhead lettuce (*L. sativa* var. *capitata*), which produces soft, smooth and tender leaves of pale to dark green colour, forming a loose spherical head. This is the most popular lettuce type in the northern Europe, and is also cultivated in Greece, particularly under cover.

(3) Crisphead, iceberg or curly lettuce (*L. sativa* var. *capitata*) is characterized by the undulate, curly and gristly leaves of very pale to dark green color, which form a spherical, dense head. It is the most popular lettuce type in northern America and in Europe is gaining importance the last few years. In Greece its cultivation seriously increased over the last decade, and together with the butterhead and loose-leaf types have impugned the dominance of romaine lettuce in Greece.

(4) Loose-leaf lettuce (*L. sativa* var. *crispa*) produces curly leaves which do not form head. Leaf color varies much in this type, ranging from pale green to red. Its economic importance in Greece has also increased with time over the last years.

(5) Stem-lettuce or Chinese lettuce (*L. sativa* var. *asparagina,* syn *L. sativa* var. *angustana*) is mainly produced in Asia for its succulent stem and the tender leaves, but it has no economic importance in Greece.

Lettuce is a cool-season crop which was traditionally cultivated from autumn until early spring, either in the field or under cover, because long days (e.g. from early spring onwards) induce flowering in lettuce plants, so older varieties were prone to bolting (premature induction of flowering). In addition, those varieties were unable to form heads in the heading types. Nowadays, the introduction of varieties that can be cultivated during spring and even summer, as they produce well before the induction of flowering, allows all-year round cultivation and availability of lettuce to the markets.

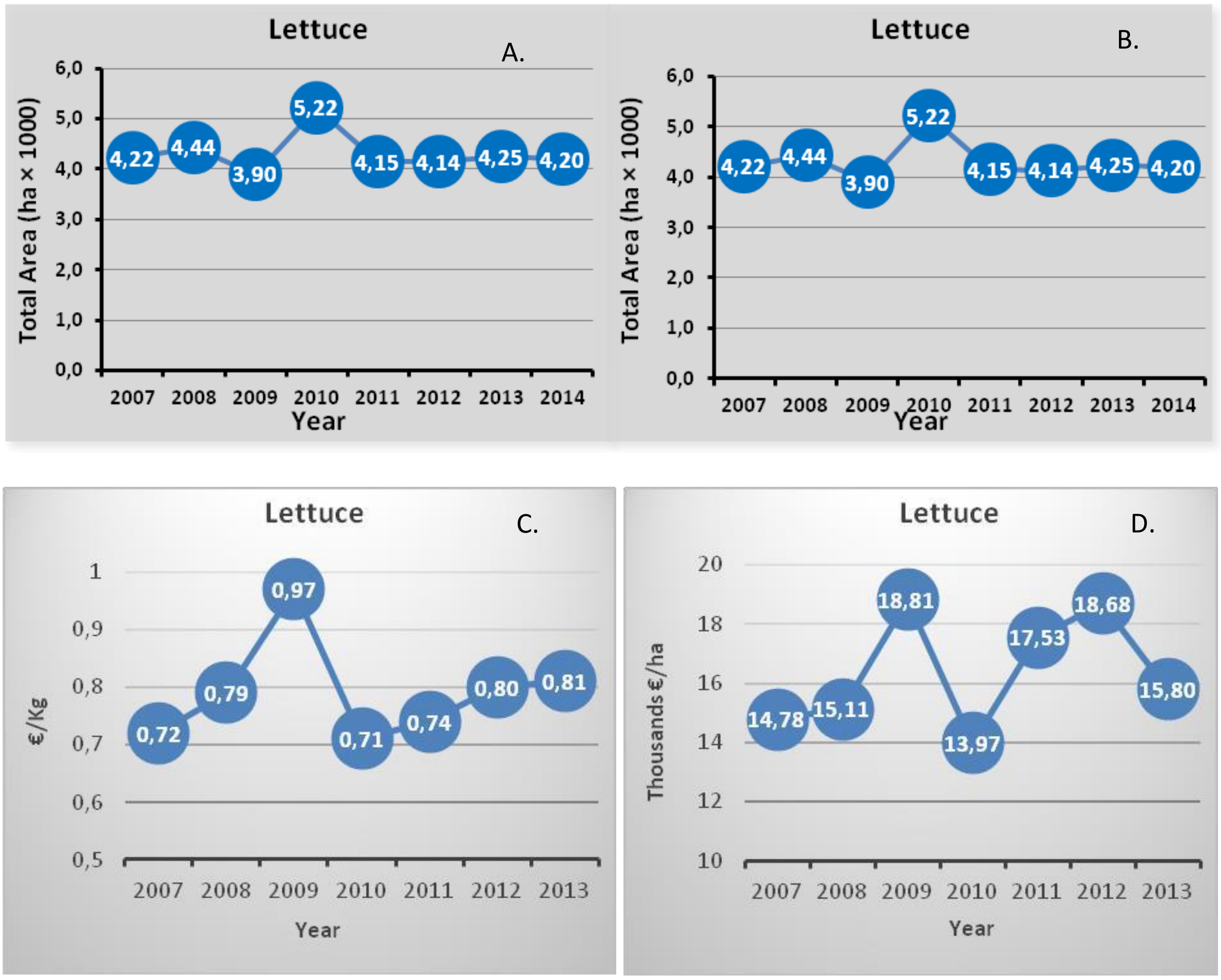

Figure 4.1. (A-D). Cultivated area (in 1000 ha - A), total production (in 1000 tons - B), farmers prices per product unit (€ per kg – C) and farmers prices per area unit (€ per ha – D) of field lettuce crop in Greece, during the years 2007-2014.

In Greece, lettuce (in particular the Romaine type) is a very popular leafy vegetable, used either fresh in salads or cooked in various dishes. It is commonly cultivated in the field and the cultivation area as well as total production are rather stable the last 7 years (Figure 4.1 A,B).

Depending on the type/cultivar and the season, field lettuce has a short cultivation cycle, which ranges from 1.5 (or autumn/spring cultivation of early varieties), up to 2.5 months (winter crops). Therefore, growers are able to cultivate several successive crops in the same field throughout the cultivation period, thereby substantially increasing yield and income. For instance, under favorable conditions in the field, 5 crops per cultivation period (e.g. August-June) can be accomplished.

As shown in Figure 4.1 (C, D) in Greece prices per kg. of produce remained rather stable during 2007-2011 (except from a sharp increase in 2009) and are steadily increasing the last 2-3 years. In contrast, farmer prices per area are more variable throughout the years and are comparatively low, taken into account that lettuce is considered an intensive vegetable crop of high inputs. From the aforementioned it is obvious that lettuce production, yield and product prices are highly variable, depending on many factors. However, in more intensive cultivation systems of multiple crops per year, farmer prices per cultivated area are expected to be much higher (see the respective business plan on field production of potato and lettuce). In addition, the employment of more intensive farming practices in field cultivation, such as dense planting, simultaneous application of irrigation and fertilization ("fertigation") and use of transplants grown in commercial nurseries, is expected to increase yields and farmers income.

In Greece, lettuce is sold by piece and not by weight. Therefore, it is crucial for the growers to produce well grown lettuce plants of good quality in order to attain fair prices. As planting spaces reduce, the number of plants per area increase; however heads tend to get smaller in size, negatively affecting their preference by consumers and farmer prices. In Greece, for both romaine and heading (butterhead and iceberg) types grown in the field typical planting spaces are 30-50 cm between rows and 20-35 cm between plants on the row, resulting in 75.000 to 220.000 plants per ha. An increase by 1 cm on planting spaces per row results in a reduction of 17.500 plants per ha.

Planting distances very, depending on differences in cultivation techniques (e.g. irrigation method), season (less closely during winter) and type/variety. Although romaine plants usually occupy less space in the field compared to butterhead or iceberg types, in Greece they are commonly planted at larger distances. Planting in rows is preferred in the field as it is easier to perform cultivation practices such as irrigation and weed control, although planting in squares allows plants to grow more uniformly.

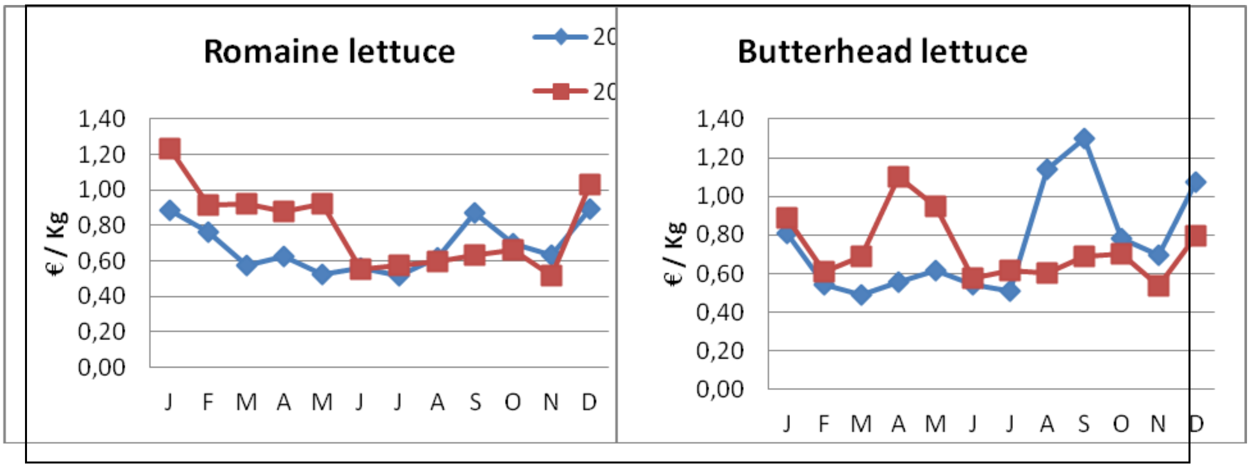

Figure 4.2. Seasonal variation of romaine lettuce (left) and butterhead lettuce salad (right) retail prices in the Central Vegetable Market of Athens, during the years 2013 and 2014.

As lettuce is produced virtually all-year round, retail prices mainly depend on the availability of the produce in relation to the markets needs at a certain period of time. From Figure 4.2 it is clear that although lettuce is primarily cultivated during the coolperiod of the year, prices are higher during winter (December-February). However, there might be also limited availability of produce in warmer periods (e.g. SeptemberDecember of 2014), most likely due to unfavorable weather conditions (e.g. high temperatures during summer, or excessive precipitation during spring and autumn). Nowadays, the increased interest of consumers in Greece for butterhead, iceberg and loose-leaf lettuce either as whole heads or in fresh-cut salads, provides a new perspective on lettuce cultivation in Greece.

In Greece, farmer prices for iceberg lettuce are higher than those of the romaine type. A farmer commonly sells in the central or retail markets of Athens romaine lettuce for 25-30 cents per head, whereas iceberg and looseleaf types range between 35-40 cents per head. Lower limits are for plants of inferior quality and when produce is sold at central vegetable markets, whereas higher prices can be achieved when there is shortage of lettuce in the markets.

Despite its high and constantly increasing economic importance and the potential to produce lettuce in Greece during winter in the field, there were large imports of lettuce in Greece during the previous decade, especially of the iceberg type, from Spain, Germany, Holland and Italy. However, the last 5 years the difference between imports and exports is greatly reduced, largely due to the limitation of imports, whereas there is a constant increase in exports, though at a low rate (Table 4.3). Some considerable efforts for exports have been observed the last few years (e.g. in the regions of Kyparissia and Euboia), mainly on iceberg lettuce. However, to extent postharvest life and to retain quality in lettuce which is susceptible to storage, transport and handling, there is a need for special infrastructure and equipment (e.g.

precooling by vacuum cooling, low temperature storage and transport in refrigerated trucks). All these considerably increase the cost of production, handling and distribution of the products; thereby exports can be made only by farmers co-operations or large retailers. Traditionally, the main areas of lettuce cultivation are near large cities (e.g. Marathonas,

Euboia, Thiva and Argolis regions around Athens, the plains near Thessaloniki etc.) so as to reduce the cost of transportation and the time from harvest until purchase by the consumers, since lettuce is particularly susceptible to wilting.

Table 4.3. Imports and exports, in quantity (tons) and value (1000 €) of Cos, Looseleaf and Iceberg lettuce in Greece, over the years 2003-2012.

Years	Iceberg Imports		Iceberg Exports		Romaine and Looseleaf Imports		Exports	
	Tons	x 1000 €	Tons	x 1000 €	Tons	x 1000 €	Tons	x 1000 €
2003	1,800	1,746	3	3	2,199	2,280	10	7
2004	5,701	1,688	25	11	2,782	1,718	14	11
2005	2,984	1,592	38	36.	528	493	28	16
2006	2,531	1,356	18	9	1,835	1,694	29	24
2007	2,092	1,304	93	45	1,293	1,049	40	22
2008	2,452	1,818	262	153	1,679	1,250	261	160
2009	1,889	1,421	87	53	1,751	1,557	138	213
2010	2,064	1,820	308	233	1,016	1,041	243	78
2011	1,013	834	280	216	724	811	368	227
2012	984	979	770	593	530	1,628	276	162

Due to favorable climatic conditions and in particular because of the increased solar radiation even during winter, lettuce plants (as well as other leafy vegetables such as spinach, rocket, endive, chicory etc.) grown in Greece, have substantially lower content in nitrates and are therefore safer for human health, compared to those grown in northern European countries with less solar radiation, especially during cool weather conditions. This serious advantage of Greek green vegetables should be exploited and promoted in foreign markets, in order to increase the exports of those products.

Although lettuce has a short cultivation cycle, crop propagation is traditionally done by transplanting. Depending on crop size, farmers either produce seedlings on their own in small-scale units, or in the case of large cultivation areas they purchase seedlings from nurseries, because of the large number of plants per ha compared to other crops that involve transplanting. Care should be taken during late spring or early autumn sowing to place seed trays at mid temperatures until seed emergence, due to the

"thermodormancy" of lettuce seeds at temperatures above 28^{o}C.

Although there are varieties that produce well under long days during late spring and even summer, lettuce plants grow better under average temperatures. Temperatures higher than 30^{o}C lead to limited growth, development of bitter leaves, promotion of bolting and failure to form heads in heading-typed plants. Lettuce is highly demanding on the type and fertility of soil. Plants do not grow well neither in acidic or alkaline soils and prefer soils with pH 6.0-7.5, particularly fertile, which withhold water, yet drain well, as the root system is shallow. They are also sensitive to soil and water salinity, which results in "leathery" leaves with dark green color and the occurrence of "tipburn" especially under high temperature conditions. As all leafy vegetables, lettuce needs N (both in nitrate and ammonium forms), in particular during the last weeks before harvest, when it accumulates more than 75% or its final weight. However, excessive N results in plants unable to form heads in the case of heading-typed varieties and also susceptible to low temperatures and diseases. In field crops utilizing drip irrigation the application of fertilizers should be done by irrigation ("fertigation"), with doses of 100 ppm N, 30-50- ppm P and 150-200 ppm K, throughout the period of plant growth, up to one week before harvest.

Irrigation is recommended to be applied by drip systems despite the initial installation cost, due to water economy, the simultaneous application of irrigation and fertilization, the reduction in diseases spreading compared to irrigation by sprinklers, the more frequent and uniform irrigation and the efficient coverage of crop needs in water. Overwatering plants in heading-types result in less dense heads, whereas uneven irrigation might cause leaf bitterness. The planting system might reduce the installation cost of irrigation system, since planting in double rows allow the use of a common irrigation line for those two rows, resulting in the use of half irrigation lines, compared to the use of an irrigation line for each planting line.

Harvest starts when plants are grown enough but before leaves getting hard, brittle and bitter. In heading-types heads must be well grown and dense. The time from transplanting to harvest largely depends on the type/variety used. Looseleaf lettuce is earlier, needing 40-50 days from transplanting, whereas butterhead and romaine lettuce take 55-70 days and usually iceberg plants need more than 70-90 days. Yields in Greece typically range between 20-25 tons/ha for heading-types and 25-30 tons/ha for romaine lettuce, although in early spring crops under more dense planting yields should rise up to 35-40 tons/ha. However, as stated before, as in Greece lettuce is sold by piece, yields should also be estimated by the number of plants per ha, instead of tons per ha. In this case, crop productivity is largely affected by plant spacing and the type of lettuce grown.

5. Guidelines for sustainable vegetable production in Greece

5.1. Integrated vegetable production and certification

Overall, the application of good agricultural practices is based on the general concept of integrated crop management. The good agricultural practices are essential components of environment-friendly and economically viable production systems relying on modern technology and aimed at producing high quality food in an efficient manner. According to the International Organization for Biological and Integrated Control of Noxious Animals and Plants (IOBC), Integrated Production (Integrated farming) is a farming system that produces high quality food and other products by using natural resources and regulating mechanisms to replace polluting inputs and to secure sustainable farming. Emphasis is put on a holistic systems approach involving the entire farm as a basic unit, on the central role of agro-ecosystems, on balanced nutrient cycles, and on the welfare of all species in animal husbandry. The preservation and improvement of soil fertility and a diversified environment are essential components. Biological, technical and chemical methods are balance carefully taking into account the protection of the environment, profitability and social requirements.

Integrated Production Management (IPM) in vegetable crops combines all cultivation techniques and means that are available and legally allowed for each crop in order to minimize input of energy and agrochemicals, while maintaining the production level. IPM is aimed not only at maximizing the production level but also at optimizing the quality of the produced vegetables. IPM practices in combination with quality management system (QMS), hazard analysis and critical control points (HACCP), workers' health, safety and welfare, environmental pollution and conservation management, have been encoded in protocols of Good Agricultural Practices (GAP). These protocols are used by certification organizations (e.g. GLOBALGAP) to provide certification of agricultural products including fresh vegetables, around the globe. As already reported in Section 2.3, certification of vegetables is currently very important for marketing.

5.2. Early production in open-field vegetable crops

From a cultivation perspective, earliness refers to the production of a fresh vegetable at an earlier time than usually produced and traded in the market. Early produced vegetables can be sold at higher prices by growers, thereby providing a significantly higher income, while they have much wider export opportunities. Early production utilizes favorable climatic conditions of specific site locations. In addition, early production can be further accelerated by special cultivation techniques. soil mulching applied in winter or early in spring (January – April) is widely used in Greece for early production. Furthermore, row cover using transpired plastic sheets to construct low tunnels further accelerates earliness and is also widely used in Greece.

Except for the usual low tunnels in which the transparent covering plastic is based on semicircular beams along the plant lines, in low height plants, simpler low coverage types may be also used (without beams or stands across the lines). This kind of low coverage is characterized as "floating low coverage" or "floating line coverage" or “free coverage” or “not supported coverage” or “floating row covers” or “direct cover”. The free coverage using non-woven synthetic sheets increases the soil and air temperature in comparison with non-coverage but may decrease the intensity of photosynthetically active radiation. Therefore, application of direct cover using non-woven fabric material may be not suitable for some cultivation sites in Northern Greece, where the solar irradiance is relatively low. Direct cover with non-woven fabric material improves not only the production but also the quality, especially in leafy vegetables, when applied in areas with high irradiance. Usually the floating covers are removed from the cultivation a few weeks after transplanting. In early cultivations in spring this happens when the ambient temperature reaches normal levels for the growth of the specific cultivated plant.

5.3. Use of shading nets

Cultivation under shading nets. The installation of shading nets above field-grown vegetables is not common in Greece but during the last years it has started appearing more often. The major objectives of using shading nets in open fields are: a) reducing solar energy intercepted by the crop, in order to reduce canopy temperature and increase pollen production in fruit vegetables, b) protection from hail and c) reduction of damages caused by birds.

The installation of shading nets is used mainly in summer cultivations of vegetables. During summer, in the Mediterranean climate, plants can be exposed in extremely high levels of solar radiation for some hours during the day. Under these circumstances, air temperature increases significantly and thus the temperature of the plant tissues (leaves, fruits) increases too. On the other hand, installing shading nets reduces the intensity of photosynthetically active radiation (PAR), thereby affecting net assimilation. If the shading level caused by the shading nets exceeds certain limits, PAR can drop to levels below the desired ones for several hours during the day, whereas on cloudy days, PAR can be insufficient during the entire day. Studies have shown that the shading effect should not be lower than 35% or 40% of the total solar radiation intensity. However, for light demanding plants, like pepper, the reduction percentage of PAR under the Greek climatic conditions should not be more than 20%. The limitation of PAR can reduce net photosynthesis, thereby restricting the marketable produce. In order to minimize the negative impact on production, shading nets should be installed during the months that natural PAR is extremely high (June – August) and - if possible - be movable.

5.4. Organic vegetable production

Organic farming systems rely on ecologically sound practices, such as biological pest control, composting, enhancement of soil fertility through biological processes, and crop rotation, while excluding the use of synthetic chemicals in crop production. However, in organic cropping systems, the nitrogen supplied to the crop is organically bound and thus the N availability to plants depends on mineralization rates of soil organic matter, which is hardly predictable under field conditions. As a result, timely supply of sufficient plant-available N can be a problem in organic agriculture and this may result in lower yields. To minimize yield losses in organic vegetable crops, timely application of organic fertilizers ahead of the sowing or planting time is needed, so as to allow for sufficient N mineralization before the establishment of an organic crop. Rotation using legume crops may considerably contribute to this goal. Legume crops are capable of providing N to the soil through symbiosis with N_2-fixing rhizobia. Nevertheless, also legume crops need exogenous supply of nitrogen during the initial cropping stages, when the N_2-fixing rhizobia are still at the proliferation stage, and thus not capable of providing N to the crop yet.

At international level, organic farming in 2011 occupied 372 million ha which corresponds to 0.8% of total cultivated area (Willer et al., 2014).This data depicts not only the importance of organic farming but also the increased developmental potential. In Greece, organic farming occupied in 2013 approximately 4,63 million ha which correspond to 5.6% of total cultivated land in the country (Willer et al., 2014). Organic farming of vegetables however occupy a very small surface in the Greek cultivated area and thus it is not recorded as separate category in statistics provided by IFOAM on organic farming per country and per category of vegetable plants (Willer et al., 2014).

According to the Ministry of Rural development and Food, in Greece organic cultivations of vegetables take in total 2.765 ha that correspond to 1.08% of the total organic cultivations' surface. Lots of modern consumers show special interest in the purchase of organic vegetables as these are considered by many scientists as of superior nutritional value compared to the conventional ones. This data indicate that the production of organic vegetables is still low in Greece compared to the relevant domestic and exports' demand.

5.5. Modern technologies in greenhouse production

The establishment of new greenhouses and the modernization of already existing installations should essentially be based on a functional design aimed at optimizing the greenhouse environment while minimizing the need for agrochemicals. Greenhouse facilities enabling maintenance of optimal climatic conditions inside the greenhouse constitute a prerequisite for the application of good agricultural practices. A functional greenhouse design includes among others sufficient static strength, optimal orientation depending on the location and the topography, use of covering materials and structures resulting in minimal reduction of light transmission inside the structure (≥ 80%), and sufficient greenhouse equipment taking into consideration the climatic conditions of the location, the crop needs, the target growing season, the fuel, land, and water availability, and the cost. Overall, tall greenhouse structures (4 - 6 m) are suggested since they provide more space for plant elongation, enhanced CO_2 reserves and a more efficient buffering of the inside temperature. Sub-optimal greenhouse height is a serious problem particularly in many Mediterranean countries, which restricts their prospects to provide high yields and optimal produce quality. The problems arising from an insufficient greenhouse height include large temperature and humidity fluctuations during day and night, and the imposition of short growing seasons in fruit-bearing vegetables, which otherwise would have a potential for long-term production (e.g. tomato).

The use of fine-mesh screens to reduce insect entry into the greenhouse has become a common practice in many countries during the last years. Insect exclusion by means of screened openings is a fundamental measure within the frame of Integrated Crop Management (ICM) strategies in greenhouses, since it is an effective means not only to reduce insect damage but also to avoid virus infections. To exclude thrips, the size of the screen openings should be lower than 190 μm, while the openings of white fly proof nets are generally lower than 290 μm (Hanafi et al., 2007). Nevertheless, a drawback of the insect-proof nets is that they impede ventilation and restrict light transmission. This problem may be tackled by increasing the surface percentage of vent openings. Another non-chemical method of pest control in greenhouses is the use of photo-selective covering materials, which may influence the insect activity inside the greenhouse. The photo-selective plastic sheets with plant-protective attributes contain specific substances which reduce or even eliminate the transmission of ultra-violet (UV) radiation (280 - 400 nm). The absence of UV radiation in the spectrum of the incoming solar radiation results in insect disorientation, thereby considerably restricting their activity inside the greenhouse, while the yield is not affected by this treatment.

In addition to the use of non-chemical pest control methods for the above–ground parts of the plants, it is essential to restrict the application of pesticides also for the control of soil-borne pathogens. According to the Montreal protocol, the use of methyl bromide as a soil fumigant was phased out since 2005 in the developed countries and since 2015 in the developing countries. To cope with this new situation, various alternatives are currently proposed and tested against soil-borne pathogens. Soil sterilization by means of steam pasteurization is an old and well-proven practice. Application of 71 °C for 30 minutes is sufficient to kill all soil-borne pathogens except few resistant weed seeds and some plant viruses, while preserving many thermophilic beneficial microorganisms. However, soil pasteurization as a means to substitute for fumigation by means of methyl bromide is not suggested for Greek greenhouses. Although the cost of purchasing a steam generator is too high for most growers, this is not the main reason for not recommending steam sterilization in Greek greenhouses. Indeed, the purchase of steam generators by farmers' co-operatives might be a solution to this problem. Actually the main reason is the cost of the fuel needed. The required amount of steam ranges between 25 and 30 kg m^{-2}, while the fuel consumption (oil) amounts to 2.4 L m^{-2}. Moreover, most growers in the Mediterranean countries do not use a central heating system in their greenhouses that could support steam pasteurization.

Grafting onto pest and disease resistant rootstocks enables greater adaptability of elite varieties used as scions to adverse environments. Grafting restricts input of agrochemicals against soil-borne pathogens and is, therefore, considered an environment-friendly cultivation technique, which is strongly recommended for integrated crop management systems. Actually, grafting provides opportunities to exploit natural genetic variation for specific root traits to influence the phenotype of the commercial elite varieties used as scions. By selecting a suitable rootstock, grafting can manipulate scion morphology and physiology thereby contributing to a better adaptation to biotic stresses including viral, bacterial, and fungal diseases and nematodes, as well as abiotic stresses such as sub-optimal temperatures, drought and soil alkalinity/acidity. In Greece, grafting is used extensively in watermelon crops to protect plants against *Fusarium* and to increase plant vigor. In melon production, grafting is also used to provide disease resistance and to increase vigor, but less extensively than in watermelon crops because fruit obtained with some rootstock/scion combinations have low quality, depending also on interactions with agricultural practices and environmental determinants that are not well understood. In recent years, the application of grafting in greenhouse tomato production has also increased. Grafted tomato plants are resistant or tolerant to several soil-borne pathogens including nematodes, fungal diseases such as *Fusarium* and *Verticillium*, and bacterial wilt caused by *Ralstonia solanacearum*. The challenge in using grafting as a means to minimize abiotic and biotic stress in fruit vegetables is to optimize yields for favorable rootstock/scion combinations through adapting and/or developing management practices for sustainable production.

Substitution of methyl bromide by other chemicals, such as metam-sodium, 1,3dichloropropene (1,3-D), chloropicrin, and their combinations have also been tested. However, the application of these chemicals requires long plant-back periods, otherwise phytotoxicity may occur. Furthermore, these chemicals are not effective against all soilborne diseases. The inoculation of the greenhouse soil with suppressive soils containing fungi and bacteria species, which act antagonistically to certain pathogens, might be an environment-friendly alternative to methyl bromide. However, the micro-organisms tested to date are specialized against one or, at best, a few pathogens, and can be used only when these particular pathogens or pests constitute a serious threat for the crop.

Soil solarization is one of the most promising alternatives to the use of methylbromide in greenhouses. This technique is based on trapping the visible and ultra-violet solar energy in the greenhouse soil by means of a polyethylene sheet, which is used as an air- and water-tight cover on its surface. Normally, most of the visible and ultraviolet radiation absorbed by the soil is converted into thermal energy, which is reemitted back to the environment as infra-red radiation. However, if the soil is fine-tilled, irrigated to field capacity, then tightly covered by a transparent polyethylene sheet, and exposed to intensive solar radiation as that prevailing in the Mediterranean countries during the summer, most of the infra-red radiation cannot escape to the environment. The prolonged exposure to these conditions results in the formation of water drops on the internal surface of the polyethylene sheet, which further restrict the transmission of infra-red radiation. As a result, the soil temperature may increase to 50-60 ^{o}C for several weeks. These conditions kill some pathogens, while favoring the growth of thermophilic non-pathogenic micro-organisms, which act antagonistically to the temperature-resistant pathogens. Thus, an acceptable level of protection against soil-borne pests is achieved for the new crop. Nevertheless, some temperature resistant weed seeds and plant viruses are not affected by soil solarization and may damage the new crops once they establish in the greenhouse soil, despite the application of soil solarization. Another disadvantage of soil solarization is that this method cannot be applied in greenhouses, which are cultivated during the summer. Nevertheless, most vegetables grown in greenhouses are not cultivated during July and August in Greece. Thus, soil solarization can be applied in most greenhouses used for vegetable production in Greece.

5.6. Hydroponic vegetable production

The soilless cultivation on porous substrates is preferred by most growers over the growth of plants in pure nutrient solution, since the latter is associated with a lower buffering capacity and poor root aeration. The main advantage of the cultivation on porous substrates is the ability of the latter to simultaneously provide both oxygen and water to the roots at a balanced ratio. Overall, the porous materials used as horticultural substrates are characterized by much weaker matrix forces compared to soil and, therefore, the plants require less energy to extract water. Consequently, plants grown in porous media at or near container capacity require less energy to extract water, while the risk of oxygen deficiency is lower in comparison with those grown in a soil near field capacity.

In hydroponically-grown vegetable crops, the only source for nutrient supply to the roots is virtually the nutrient solution. Therefore, all essential plant nutrients should be supplied via the nutrient solution, with the exception of carbon, which is taken up from the air as CO_2. To prepare nutrient solutions containing all essential nutrients, inorganic fertilizers are used as nutrient sources, with the exception of iron, which is added in chelated form, to improve its availability for the plants. The Laboratory of Vegetable Crops of the Agricultural University of Athens has created a computer program that can easily be applied to calculate the amounts of fertilizers needed to prepare commercial nutrient solutions when a target composition is available and the mineral composition of the irrigation water is known. This computer program, which operates via a Microsoft EXCEL® platform, can be freely accessed by hydroponic growers via Internet at: www.ekk.aua.gr/excel/index_en.htm.

In the last decades, the cultivation on inorganic substrates is characterized by a shift from open to closed-cycle cultivation systems, which involve re-use of the drainage solution. The cultivation of greenhouse crops in closed hydroponic systems can substantially reduce the pollution of water resources by nitrates and phosphates stemming from the fertigation effluents, while contributing to an appreciable reduction in water and fertilizer consumption. The switching-over to closed cultivation systems does not seem to restrict crop yield or product quality. However, a factor limiting the broad expansion of the closed-cycle cultivation systems in substrate-grown crops is the accumulation of salt ions in the recycled nutrient solution. This phenomenon originates from inlet of salt ions and water at higher ratios (concentrations in the irrigation water) than the corresponding ion to water uptake ratios. Besides the use of good quality water with low salt concentrations, a model-based replenishment of nutrients absorbed by plants in closed-loop hydroponic systems might appreciably increase the accuracy of operations, thereby effectively preventing the depletion of nutrients, while at the same time minimizing the increase in total salt concentration.

In substrate-grown crops with free drainage of the run-off solution, a certain percentage of the nutrient solution supplied to plants is aimed at salt leaching and compensation for the variability in water supply between individual emitters (Sonneveld, 2002). However, the drainage fraction should be maintained at the absolutely necessary minimum in order to minimize waste of water and fertilizers and environmental pollution with nitrates and phosphates. In open cultivation systems, typically leaching fractions of 25-35% are recommended (Schröder and Lieth, 2002). On the other hand, in closed-cycle cultivation systems the drainage percentage is not restricted by environmental concerns and hence the irrigation frequency may be considerably higher than that resulting in leaching fractions recommended for open cultivation systems. A high irrigation frequency may improve crop performance due to a higher availability of nutrients, specifically P and Mn. Furthermore, high irrigation frequency is associated with constantly elevated moisture levels in the root zone of substrate-grown plants which increases the hydraulic conductivity of the substrate and thus also the availability of water to the crop.

Current developments in the cultivation of greenhouse crops on substrates include the use of grafted plants in fruit vegetables such as tomato, the use of silicon in the nutrient solution, which can increase plant resistance against salinity and some pathogens. In the near future, the use of on-line monitoring tools to automatically link in real time the fertigation requirements with the constantly changing environmental conditions is expected.

6. Discussion

6.1. Summary consideration of capacity and prospects in vegetable production

The climate of Greece is characterized by mild winter and extensive sunshine periods, parameters that make the country an ideal place for the production of good quality vegetables at low cost. The warm climatic conditions, especially in southern Greece, favor the early production of vegetables, i.e. earlier than they are usually produced in other sites or countries. Due to the fact that early vegetables are produced in specific places and in restricted quantities, they face less competition. They are thus traded easier and at higher prices not only in the domestic but also in export markets. Greek watermelon is an example of an early vegetable with high exports. The early production of watermelon in Greece starts usually between May 20 to Messenia 25, particularly in the regional units of Ilia, and Messenia, as well as in Crete. Early production at these sites is achieved by planting towards the end of February or the first week of March using mulching (black-white plastic sheets) and low tunnels. The average sales price during the end of May and the first two weeks of June are double as high as the summer prices (see Annex), and thus they can recoup the higher cost generated by the application of mulching and low tunnel, leaving also a higher economic benefit to the growers. The early production of watermelon is partly sold at higher prices in the domestic market and partly exported. As shown in the Annex, the Greek exports of watermelon amounted roughly to 150,000 - 200,000 tons $year^{-1}$ in the last ten years, which corresponds to about one third of the total domestic production. Similar opportunities are provided also for melon, bean, zucchini squash, and other warm-season vegetables (see Annex), as well as for asparagus. In addition, cool-season vegetables (e.g. iceberg lettuce, see Annex) destined for the export may be produced in open field during most of, or even the entire cool season. Thus, early field production of warm-season vegetables and winter production of cool-season vegetables destined for the export is an economically viable business in the agro-food sector. However, opportunities for early vegetable production are provided only in areas located in southern Greece, particularly in low altitudes characterized by mild-winter climate.

In addition to early production, late open-field production of warm-season vegetables such as tomato and eggplant in the fall (October and November) is also a viable business in the agro-food sector. Late production does not incur extra cost for seedling production in heated nurseries and low tunnels and has, therefore a lower cost. On the other hand, most warm-season vegetables achieve much higher sales prices after September (see Annex), because at that season of the year they are mainly produced in greenhouses, while in the open field they can be produced only in areas with mild climatic conditions. Thus, areas with mild climatic conditions in southern Greece provide optimal opportunities also for late-season production of warm-season vegetables, which is also a profitable business in the agro-food sector.

The Mediterranean mild winter of Greece provides excellent natural conditions for out of season production of vegetables at a low cost for heating. Therefore, protected cultivation and especially greenhouse production is considered a major agricultural sector in Greece with good prospects for further development. This is particularly true in coastal areas, especially in Peloponnese which is located in southern Greece, and the Greek islands such as Crete. The boost of vegetables production in greenhouses that was observed since 1960 internationally and in Greece changed radically not only the way vegetables are produced but also the nutritional habits of consumers. Greenhouse production facilitated the availability of almost all vegetables, regardless of the traditional production season. Out of season cultivation gave the opportunity to growers to prolong their annual working time, increasing also in this way their income. Out of season cultivation needs more fixed assets and mechanical equipment investment and thus pushed vegetable production towards a more industrialized and technically advanced production sector, while also increasing the anticipated profit margins. At international level, modern vegetable producers focus not only on yield increase but also on the reduction of energy and chemical inputs while not compromising quality and consumer safety. Greek producers need to follow modern international trends in order to sustain and further increase the quality characteristics of their products and their overall competitiveness. This goal presupposes appropriate knowhow regarding new environment-friendly and technologically advanced methods and cultivation systems.

In addition to the cultivation techniques, current and new vegetable growers need to take into consideration new trends and conditions in the domestic and global market. An example of the new conditions that are currently prevailing in the vegetable market is the requirement for certification of the production process by accredited certification bodies, which is a prerequisite for the export to north European markets. The certification has already created new conditions in the vegetables production since it sets new standards and requirements not only in the production techniques but also in the overall organization of the vegetable production units/companies.

Other parameters of vegetable production that need further improvements and adjustments include:

- selection of proper cultivars,
- rational usage of irrigation water and fertilizers,
- further modernization of cultivation practices and techniques like hydroponics,
- proper rotation schemes
- quality grading following rules on variety, size, shape, color, homogeneity, and implementation of standards regarding sanitation, packaging and labeling. Furthermore, there is an urgent need for the establishment of local cooperatives in important production centers in order to improve the standards and reduce the cost of packaging, organize more professionally the marketing of the produced vegetables, and improve the products' branding in correlation with the application of relevant certification (GLOBALGAP, ISO, environmental footprints, etc.).

6.2. Opportunities in the vegetable production sector for new and experienced growers

Early production of warm-season vegetables in open field entails much lower cost than greenhouse production, and provides therefore an easier entry to youth into an agro-food sector career path. Late-season production of vegetables is associated with an even lower investment when starting a new business as a professional producer. Thus, producing vegetables in the open field early or late in the season by taking advantage of the favorable climatic conditions in selected areas in southern Greece provides excellent opportunities for young people to find a position as producers in the agri-food sector.

Greenhouse production using modern technologies such as efficient climate control, grafting of fruit vegetables, and hydroponics, results in high incomes per cultivated area unit (see Table 3.2). Therefore, the greenhouse sector provides also good opportunities to young people who can afford an initial investment cost to construct a greenhouse or they can find financial opportunities for this. Automated control of the greenhouse climate, as well as fertilization and irrigation especially in modern hydroponic systems require the application of computer-controlled systems and new technologies. The young people are much more familiar with such technologies and can thus be much more successful in this area than older greenhouse producers. There are however two factors which are perceived as barriers to entry into the greenhouse sector. The first factor is the initial investment cost, which is higher than that needed for openfield crops. The second factor is associated with the higher requirement for knowhow. On the other hand, greenhouse production provides much higher income per cultivated area and utilizes much more efficiently the agricultural land in areas with mild climatic conditions. Thus, young people originating from regions with favorable pedo-climatic conditions are advised to look for financing opportunities (from state or private sources) in order to establish a greenhouse enterprise. Examples from countries with similar climatic conditions, such as Spain (Almeria) and Turkey (Antalya), point to a high potential for economic development in areas with mild-winter climate, such as those in Central and Western Greece, Peloponnese, Crete and other Greek islands.

In the last two decades, there is an increasing interest among Greek consumers for organic vegetables. Due to the increasing consumers' interest, organic agriculture is expected to expand in the next years in Greece but also abroad. Consequently, organic vegetables produced in Greece have a big potential of being sold in the domestic and in the international markets. In order to further develop the prospects of organic vegetables production in Greece, there is a need for coordinated efforts that will highlight the nutritional value of Greek organic vegetables. Moreover improvements in production techniques are needed in order to reduce the losses from plant diseases and inadequate plant nutrition. Last but not least, organization in local or regional cooperatives is very important in order to improve facilities for packing and storage and establish long-term connections to large national and international markets.

6.3. Vegetables: Consumer habits and growth potential, as well as export potential

An appreciable percentage of Greeks are used to consume local varieties of vegetables with special characteristics, such as eggplant 'Tsakoniki", tomato "Santorini", melon "Argitiko", wateronion of Zakynthos, Okra "Bogiatiou" and "Pylaias", artichoke "Argitiki", etc. A systematic production and supply of such varieties to the market after proper package under strict quality control would certainly find a place in the market at reasonably high prices. Well packed and labeled local varieties subjected to strict quality control might even be brand named. Introduction of some of these traditional varieties to greenhouse, so as to extend the season of their availability on the market might develop to a profitable business in the agro-food sector.

Improvements in the transport infrastructure within EU, constantly attenuate the problems in competitiveness of the Greek vegetables caused by the long distance between production and consumption centers in central and north European countries. However, the most promising opportunities for exports of fresh vegetables in the last years occurred as a result of the opening and expansion of new markets in

Balkan countries. Greece has clear advantages over Spain, Italy, Morocco or the Netherlands in terms of transportation cost and freshness of vegetables and this is anticipated to further increase the export potential of Greek vegetables to these countries. Greece produces vegetables such as watermelon, melon, tomato, zucchini, potato and many other commodities at low cost in the field much earlier than all other countries in south Europe. The latter can produce locally these vegetables only in greenhouses which entail much higher cost and thus are much less competitive.

In lowlands of central and southern Greece, vegetables can be produced up to late November in open fields. The production in fall in these parts of Greece relies only on favorable climatic conditions without any heating needs for seedling production or any other special cultural practices and, therefore, their production cost is low. Thus, late open-field production of warm-season vegetables in autumn provides currently good opportunities not only for selling at reasonably high prices in the domestic market but also for exports in neighboring countries in Southeastern Europe. A similar export potential to southeastern European countries is provided also for the domestic production of vegetables in greenhouses during the cool season of the year, because of the temperature difference which entails much lower production cost in Greek greenhouses.

6.4. Regional considerations in vegetable production

Local climatic conditions and distance of production sites from consumption centers determine relative advantages and disadvantages of different regions within the country with respect to vegetable production. Thus, for instance, field crops for early production of warm season vegetables are located mainly in southern geographical regions and especially in Peloponnese, including the regional units of Achaia and Ilia. These two regional units are geographically located in Peloponnese but allocated to the Administrative Region of Western Greece. Especially the western part of Peloponnese (Achaia, Ilia, Messenia) is most suitable for early production of vegetables because it combines warm climate characterized by mild-winter with sufficient water resources due to the much higher yearly rain precipitation (e.g. 920 mm in Ilia) in comparison with eastern Peloponnese (e.g. 490 mm in Argos).

Crete has the most favorable climatic conditions for out of season production of vegetables in greenhouses in terms of ambient temperature during the cool season. Thus, for instance, the monthly minimum and monthly average temperatures in the coolest month of the year (February) are 8.7 and 12.9 ^{o}C, respectively, in Ierapetra on the island of Crete, 5.7 and 10.6 ^{o}C, respectively, in Kalamata (Southwest of Peloponnese), but 2.2 and 6.7 ^{o}C,, respectively, in Thessaloniki (Hellenic National Meteorological Service, 2015). Therefore, most of greenhouses are currently located in Crete (46% in 2012 according to the Ministry of Rural Development and Food, see Table 2.6). Southern locations (e.g. Crete) provide benefits to out of season production of warm-season vegetables in greenhouse not only due to higher temperatures but also due to higher light availability. In comparison with northern Greece, the southern regions are characterized by more hours with sunshine resulting in higher mean daily global radiation during the winter months, when light may be a limiting factor for greenhouse production.

Although southern regions such as Crete, Southern Aegean Islands and Peloponnese provide clear advantages for out of season greenhouse production in terms of temperature and light, some areas in Northern Greece seem to provide advantages in terms of energy cost for heating and transportation cost, thereby overcoming the climatic advantages. In particular, Macedonia and Thrace in northern Greece were preferred over Crete or Peloponnese by investors in the last 10 years for the establishment of modern and fully equipped, large greenhouse units (e.g. Agritex, Wonderplant). This was because of the availability of natural gas for heating which was utilized for electricity co-production, thereby minimizing the greenhouse heating cost. Another modern greenhouse unit, Thermokipia Thrakis, was founded in Thrace despite the less favorable temperature and light conditions, because of the possibility to utilize geothermal water for heating. Sites with geothermal water are available also in other regions (e.g. Arta) and might be selected for greenhouse vegetable production.

One has to take into consideration that lowlands in northern regions of Greece and especially near coastal areas provide clear advantages for greenhouse production in the warm season of the year, when the too high temperature is the limiting factor for production in southern Greece. Greenhouse production in the summer and early fall is profitable for some crops like cucumber and tomato. The greenhouse cultivation of cucumber in the summer is important because the female seedless cultivars cannot be grown in open field due to unwanted pollination and poor produce quality. Similarly, summer tomato production in greenhouses equipped with cooling facilities and insectproof screens is a means to overcome problems of poor fruit set due to excessive ambient temperatures, infestation by insects, and occurrence of virus diseases transmitted through insects. Excessively high summer temperatures may minimize pollination during July and August in open field crops thereby decreasing the production in September and October. Thus, northern regions within Greece may be more suitable for greenhouse production of a warm-season vegetable during the warm season of the year focusing on early spring and late fall production, when prices are higher (see Annex), while growing a cold season vegetable in the winter, such as lettuce. This production scheme is not competitive to that applied in southern Greece, where the greenhouses are mostly used to grow a warm season vegetable from September till next June, while in July and August they remain uncultivated.

With respect to field crops, areas with cooler climatic conditions in northern Greece may be more suitable for asparagus production, because the exposure of rhizomes to low temperatures during the winter has a positive effect on quality of white spears harvested in the spring. Furthermore, fields located in northern Greece and even in highlands are suitable for summer and fall production of cool-season vegetables, such as potato, cabbage, cauliflower, broccoli, leek, spinach, celery, etc.

Another important aspect related to the capacity and prospects of different regions for vegetable production is the distance from consumption centers and the concomitant impact on transport cost and quality. For instance, greenhouse vegetables from Crete require about 12 to 24 hours longer to reach the central market of Athens than those from Peloponnese. This has a negative effect on both transport costs due to the sea journey from Crete to Athens, and quality due to longer time between production and arrival at the Central Market of Athens. When these vegetables have to be transported to other cities and especially islands, which require an additional sea journey, further negative effects on transport cost and quality are incurred. On the other hand, the disadvantages for Crete and other large centers of vegetable production in terms of transport cost and quality maintenance, which affect also imported vegetable commodities, provide advantages to young people in other Greek islands and remote provinces all over the country. Indeed, the high cost and the concomitant quality deterioration of vegetables transported to such places provide opportunities to local youth to establish vegetable production enterprises aiming at supplying the local market. Great opportunities for local vegetable production in greenhouses or screenhouses during the summer are provided especially to young people in the Greek islands, most of which are characterized by mild climatic conditions, because they can supply the strongly increased demand arising from tourism. An additional opportunity is the local production of organic vegetables in greenhouses and screenhouses during the summer in touristic centers, which can be combined with the build-up of the local kitchen (see also sub-section 6.7) .

6.5. Stakeholder analysis in vegetable production

Stakeholder participation is essential in the design strategy for the expansion of employment opportunities for youth in the Greek vegetable production chain. Greek vegetable production chain has many primary and secondary stakeholders. Each of one engages different groups of the chain and has a different market orientation. Thus, it is crucial to identify the relationship between the various stakeholders, as well as the impact of their actions in each different target group of the chain. Specifically, in Greece one of the most important group of players of the vegetable production sector is the small farmers. The highest percentage of cultivated area in Greece is owned and managed by small farmers due to social and geographical reasons, which have led to considerable fragmentation of Greek land. A significant amount of vegetables that are sold in the local and urban open markets are traded directly by the small farmers or even in some cases by small scale vegetable traders. It is obvious, that the intermediate traders that very often handle the production before it reaches the final market further lower the net profit of small farmers. Hence, small farmers have less capacity to invest in order to increase their productivity and the added value of their product. One solution to deal up with these problems and improve the competiveness of small farmers is the organization of producer groups. However, until now few attempts have been made to this direction especially in the vegetable production sector, whereas the most noteworthy examples are in the southern Greece (Crete). On the other hand, the Greek vegetable production sector includes also large-size producers not only in terms of cultivated area but also in terms of equipment and technology. The produce of large-size farmers is mainly distributed through big retailers, either Greek or acquired by foreign retail chains. It is estimated that 80% of total retail trade value regarding vegetables and fruits is attributed to the large retailers, whereas the remaining percentage is separated to the local markets and shops (Rigakis, 2012). Large-size farmers due to their capacity and product driven competitive advantage have the opportunity to establish business partnerships directly with HORECA industries. This option offers them the potential to expand further their customer base in the agro-food sector. Wholesalers are also another stakeholder that plays important role in the vegetable production sector. The biggest fruit and vegetable wholesalers have settled their facilities in the Central Wholesale Markets of Athens and Thessaloniki or near the biggest farming areas. Wholesalers channel is heavily linked with the distribution of vegetables to the domestic market either by their own logistic network or by cooperation with transport companies. Last but not least, another major stakeholder is universities and research institutes. It is undisputable that a strong relationship is needed between the Greek agricultural universities, research centers and the vegetable producers to increase the competitiveness of final products and develop significant horticultural achievements that will promote the Greek vegetable production chain.

6.6. Synergies with other food production sectors and agro tourism

One important sector that could be closely correlated with the vegetable production is organic farming as there is a big consumer demand for organic vegetables. During the last decade the organic market grows as the consumers worry about the use of pesticides and chemicals during the vegetable cultivation. However, in Greece the percentage of organic vegetable farmers correspond to approximately 1% of total organic farmers which means that there is big room for development in this sector. On the other hand, Greek farmers are not convinced to apply organic practices and abandon the use of inorganic fertilizers and pesticides to cultivate their vegetables jeopardizing their high yields that obtain in conventional practices.

Linkages between agro-food sector (in our case vegetable production) and agrotourism can offer significant opportunities for the development of both sectors in Greece. With the establishment of a close connection between the vegetable production sector and the tourism industry, entrepreneurial of small vegetable companies that are located in touristic areas can be expanded, whereas local communities will have economic development opportunities. Agro-tourism is an efficient and direct way to make Greek vegetable products well-known all over the world. Unfortunately, agrotourism industry has not be related with vegetable production sector efficiently at least up to now, but is mainly connected with wine and olive oil production. Local vegetable products could be more promoted for their unique characteristics (taste, appearance), the way of cultivation, their climate preferences, as well as their linkage between the Greek culture and heritage. Greek agricultural regions could be transformed in important touristic destinations, whereas typical touristic areas could be more expanded based on agro-tourism this time. It has to be mentioned that HORECA industries can play an important role in agro-tourism as are mainly affected by tourism industry and especially in the summer period.

6.7. E-commerce in vegetable production

E-commerce is a rapidly developing business strategy which has been established also in the agrofood sector, including the vegetables production. In particular, vegetable e-commerce is the commercial evolution of vegetable production sector, as it can operates as an additional trade channel for producers, retailers and wholesalers. Thus, ecommerce can play an important role in the expansion of the customer pool. The ecommerce markets that can be implemented in the vegetable production sector are distinguished in three categories. In the first category e-commerce is operated by producers or wholesalers which are selling vegetables to the retailers or even final consumers via e-market. The second category of e-commerce market is operated by agribusinesses which are selling all the necessary products (agrochemicals, propagating material, etc) for the vegetable production to the growers. In the last category it is included the specialized services to the producers that are provided through e-market such as logistics and transportation. However, in Greece the companies that operate via e-commerce of the first category are mainly using e-market to expand their exports channels and not to serve the needs of domestic market where there is a room of development. In recent years a few attempts have been made also in Greece related ecommerce especially from small scale companies that producing their own vegetables or from vegetable wholesalers. In these cases the suppliers give the choice to the customer to select the quantity and many times the origin of vegetables via e-market and they are finally delivered at customer's spots.

6.8. Analysis of imports and opportunities for Greek-produced substitutes

As stated in Sub-section 2.3, Greece is a net exporter of vegetables with an export to import ratio of 1.83:1 in 2012 in terms of volume and 1.77:1 in terms of value. Furthermore, the data in Figure 2.1 and Table 2.1, show a constantly increasing trend for the exports and a constantly decreasing trend for the imports. Thus, the exports of tomato are now higher than the imports while in the past the inverse was the case. Despite this fact, the imports of vegetables can be further substituted by domestic production, especially for some commodities.

The highest imports are those of potato, with an average quantity of 114,391 tons and an average value of € 38 million during the years 2000-2014 (see Table 2.3). The imported quantities of potato are much higher than those exported as indicated by the export/import ratio which averaged to 19.7% during the years 2000-2014 (see Table 2.3). Potato has a cultivation cycle of about four months. Planting of potatoes in Greece commences in late November (Messenia, Crete) and continues by mid-August in different regions of the country. Consequently, the first harvest starts in mid-April and the last in early December. Therefore, there is an interval of approximately 4 months from the beginning of January till mid of April, during which there are no fresh potatoes in the market. Furthermore, early production of potato from mid-April to mid-June as well as late production from October till beginning of December is restricted to areas with mild climatic conditions in southern Greece (mainly Ilia, Messenia, Crete, Naxos). However, even in these areas there is a competition for available land with other vegetables that may render a higher net income than potato. As a result, especially from January to April the domestic production is incapable of covering the domestic demand and this provides opportunities to other countries, such as Egypt and Cyprus for exports. Nevertheless, imports of potato at variable quantities are needed almost throughout the year and this means that there are opportunities for Greek producers to substitute local production for these imports with. In the last years, Greek potato growers attempted to produce earlier in Spring (March) and even in the winter in high tunnels, but with mediocre success so far. Further attempts to this direction are needed, based also on research to detect and address the shortcomings in these practices.

In former years, Greece used to import substantial amounts of tomato as well (15,000 to 20,000 tons per year during 2004-2012). These amounts were almost halved in the last two years, while the exports increased considerably (see Table 3.3). Nevertheless, improvements in quality and the average yield performance might further substitute domestic production for imports.

Other imports of vegetables that might be substituted by local production include mainly those of colored blocky peppers, onions, garlic, celery, carrots and iceberg lettuce. Colored blocky peppers, which are produced in the greenhouse, provide good opportunities to Greek greenhouse producers and especially young people wishing to enter the agro-food sector, but this needs the establishment of well equipped greenhouses enabling maintenance of proper temperature levels. Sites with an advantage in the heating cost (e.g. areas with geothermal water or cheaper energy sources to couple greenhouse production with electricity production) are most suitable, but the mild climate of Crete also provides possibilities for the production of colored blocky peppers.

6.9. Prerequisites to entrepreneurial success (critical success factors)

Every entrepreneurial journey has some critical factors that play a significant role in its success. Motivation of the Greek Youth must take place in a way that can facilitate the initiation of its efforts and investment. Being motivated is a key enabler that sets the framework in order for young farmers to set up their business, apply professional methods for its development, strive for increasing performance and persist in achieving always better results. Appropriate education and specialization are critical factors for the success of an endeavor in this sector. Agricultural education and even specialization in the specific area that someone desire to activate are critical parameters that affect the success of the overall effort as the young farmers can by their own knowledge and expertise assess challenging situations, become problem solvers, define the management directions by themselves and take full ownership and responsibility on their own business. It goes without saying that professionalism and organization are prerequisites for any agricultural business success and unfortunately are lacking in the majority of Greek farms. Regardless of the investment or the hard work needed in order to engage in such an endeavor, the strict professionalism and the accompanying organization are needed and guarantee the basis for a successful result. Management of an agricultural business is a critical success factor that sets the framework for the overall coordination of all business pillars that define its performance. Pointing out some of the most important aspects, there must be a proper financial management (i.e. assessment of customers' credit risks, control of accounts payables), sales & marketing management (pricing management, customers' pool, dependency on big customers, loyalty schemes) and last but not least supply chain management (selection of suppliers, payment terms, inbound and outbound transportation, etc). Market research also plays a significant role in the financial results of these startups. A very careful study over the market needs/opportunities and the mapping of all critical stakeholders (transportation, suppliers, competition, legal framework) is vital in order to safeguard the investment but also provide all necessary information for the appropriate positioning in the market that will increase profit margins.

6.10. Recommendations for consideration in the Implementation Phase

One of the conclusions of this study is that the further development of the vegetable production sector is hampered to an appreciable extent by factors associated with shortages in knowhow. Thus, in the implementation phase, it is important to support existing and new vegetable growers with knowhow in several directions. These can be summarized as follows:

6.10.1. Open field

- Improvements in watermelon and melon production has to be based on selection of new cultivars, which produce fruit with more attractive characteristics for export, and improvements in the fruit quality by selecting the most appropriate rootstock/scion combinations. Special attempts are needed expand the cultivation of seedless watermelons, which are very attractive for many consumers, especially in north European countries.
- The open-field production of iceberg lettuce winter for export in sites with mild climatic conditions has to be considered and supported by knowhow and experimental work to assess possible local difficulties.
- The production of potato in the winter and March in low-cost greenhouses aiming at substituting for exports, accompanied by brand naming as Greek potato, a characteristic that is appreciated in the domestic market, has to be tested experimentally both in research institutions and stakeholders' fields.
- Organic production of vegetables using legumes in rotations, as green manures, or also as green mulching needs special attention

6.10.2. Greenhouse

- Grafting of greenhouse vegetables provides several advantages to plants exposed to biotic and abiotic stress and needs to be considered for tomato, cucumber, eggplant, melon, and watermelon greenhouse crops.
- Organic vegetable production in Greek greenhouses is limited, mainly due to insufficient knowhow and needs to be supported.
- Improvements in greenhouse production and competitiveness have to be based on modern technology, focusing mainly on efficient control of the inside microclimate and hydroponic production to improve nutrient and water supply and efficiently control the soil-borne pathogens. The establishment of a pilot hydroponic greenhouse in AUA that might be used for the training of new and existing greenhouse growers might considerably contribute to transfer of knowhow in this production sector.

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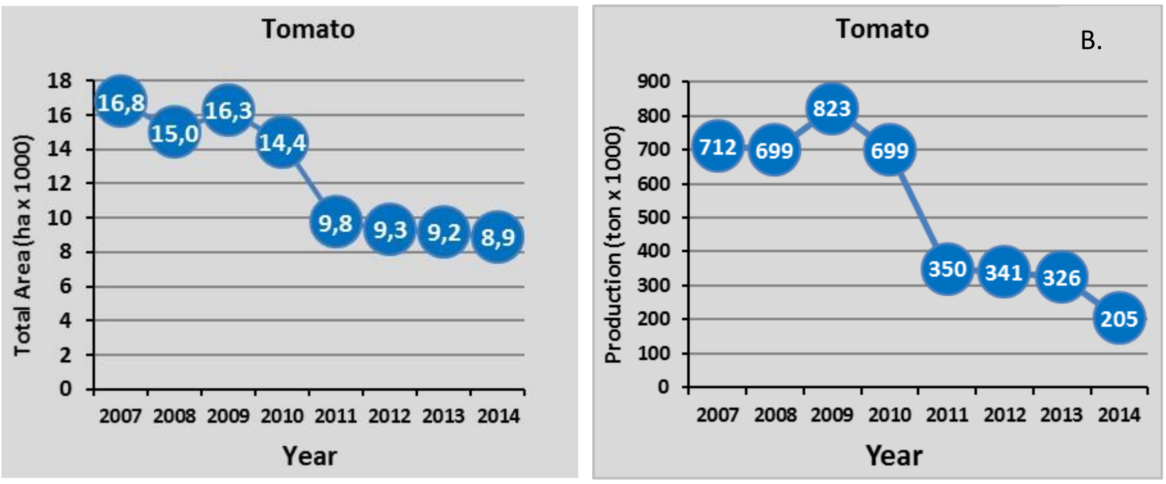
1. Survey of possible alternatives for viable vegetable production enterprises

1.1 Open-field vegetable production

1.1.1 Tomato (*Solanum lycopersicum* L.)

Tomato is a major horticultural crop with an estimated global area of 4.8 million ha and an overall production of over 160 million metric tons, including fresh tomato grown in greenhouses and field crops for both fresh consumption and processing (F.A.O. 2012).



A.

Figure 1 (A-B). Total area (A) and total production (B) of fresh tomato cultivated in open fields in Greece during the years 2007-2014.

In Greece, the open fields cultivated with fresh tomato are extended over a total area ranging from 8.900 to 16.800 ha during the years 2007 to 2014 (Figure 1A). The obtained production during these years ranged from 341.000 to 699.040 tons (Figure 1B). From these data, an average yield of 36,6 ton ha^{-1} is calculated for open-field fresh tomato in Greece. This yield level, which is obtained by harvesting for 2-3 months, is considered low and has a potential to increase. In most cases, harvesting of field tomato starts by the end of June or beginning of July and ceases in September or October. Yield increases in field tomato crops can be achieved mainly by: a) selecting productive cultivars, b) properly training and supporting the crops (staked tomato) and c) shading from mid-June to mid-August to reduce excessive canopy temperatures that restrict pollen formation in anthers and pollen germination on the stigma. Especially the very high temperatures in July suppress fruit setting due to reduced pollen production and dryness of the stigma, with detrimental effects on yield harvested in September. Furthermore, the too high summer temperatures increase the incidence of the physiological disorder blossom-end rot (BER) thereby strongly restricting the percentage of marketable produce.

Table 1. Cultivated area and production of fresh tomato in open fields allocated into the 13 regions of Greece in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area (ha)	(%)	Total production (ton)	Mean production (ton/ha)
Eastern Macedonia & Thrace	540	61	6,739	12.47
Central Macedonia	746	8.4	20,182	27.06
Western Macedonia	181	2.0	6,683	36.97
Epirus	528	5.9	11,786	22.32
Thessaly	392	4.4	14,951	38.15
Ionian Islands	533	6.0	440	0.83
Western Greece	1,045	11.7	26,145	25.02

	960	10.8		
Total	8,907	100		
Central Greece	1,319	14.8	42,027	31.86
Attica	363	4.1	875	2.41
Peloponnese	1,933	21.7	29,100	15.05
North Aegean Islands	75	0.8	1,915	25.70
South Aegean Islands	292	3.3	2,926	10.01
Crete			41,250	42.97
			205,018	23.02

As can be concluded by the geographical distribution of fresh tomato cultivations in open fields, which is shown indicatively for 2014 in Table 1, the leading region in field tomato production for fresh consumption is Peloponnese followed by Central Greece and western Greece. This distribution shows that the major factor that determines allocation of tomato production over the country is the proximity to the large markets and consumption centers (Athens and Thessaloniki) and thus the transportation cost.

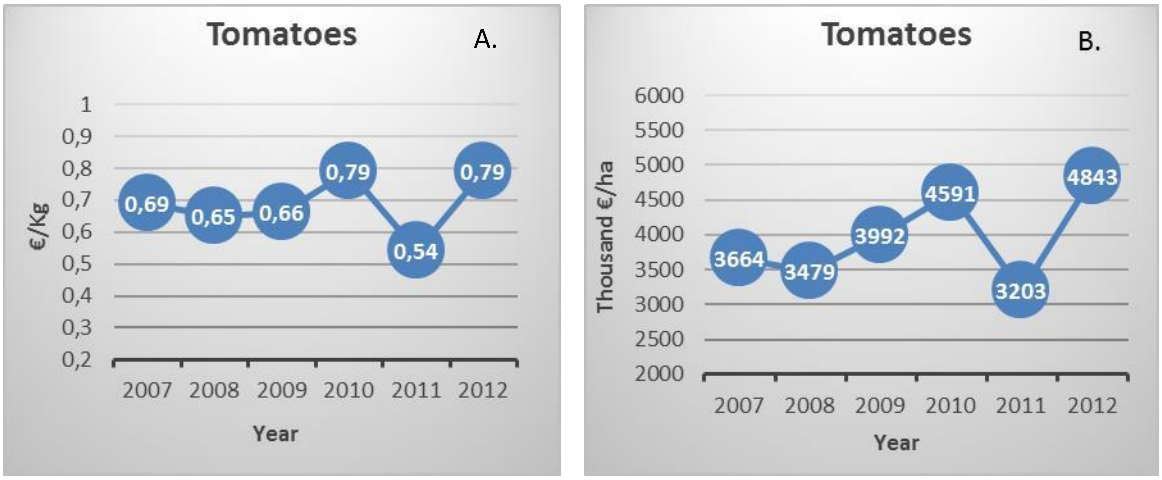


Figure 2 (A-B). Mean yearly prices paid to growers for fresh-market tomatoes, including produce originating from both, open fields and greenhouses (A), and mean gross returns (B) during the years 2007 - 2012 (data from the Greek Ministry of Rural Development and Food).

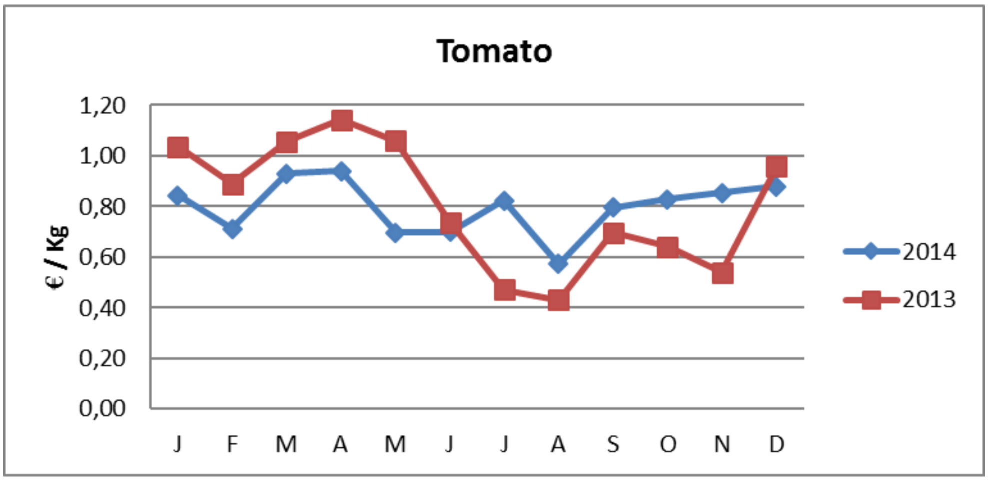


Figure 3. Mean monthly prices for fresh-market tomatoes during the years 2013 and 2014 at the Thessaloniki Central Fresh Fruit and Vegetable Wholesale Market.

Mean yearly prices paid to growers for fresh-market tomatoes during the years 2007 - 2012 according to data of the Greek Ministry of Rural Development and Food (MRDF) are shown in Figure 2A. The mean price over the six years amounts to €0.69 per kilogram. However, this price is an average for the whole year, including the months from November to June, when only greenhouse tomato is sold in the market. The prices of tomatoes originating from open fields are better indicated by considering the evolution of wholesale market prices per month, which are shown indicatively for 2013 and 2014 in Figure 3. These data show that the prices of tomato in the summer months (July to September), when the open-field fresh tomato is sold in the market, ranged between 0.43 and 0.80 € kg^{-1} with an average of 0.63 € kg^{-1}. The cost of openfield tomato production is estimated to range from 0.30 to 0.35 € kg^{-1} and thus, for a total yield of 40 ton ha^{-1}, an average net income of about 12,000 € ha^{-1} is expected from a field-grown fresh tomato crop.

1.1.2 Potato (*Solanum tuberosum*)

Potato basically originates from Peru. In Greece, potatoes were first cultivated in 1828. It is the third plant in nutritional value following wheat and rice. However the yield of carbohydrates and proteins per hectare is significantly higher than wheat and rice.

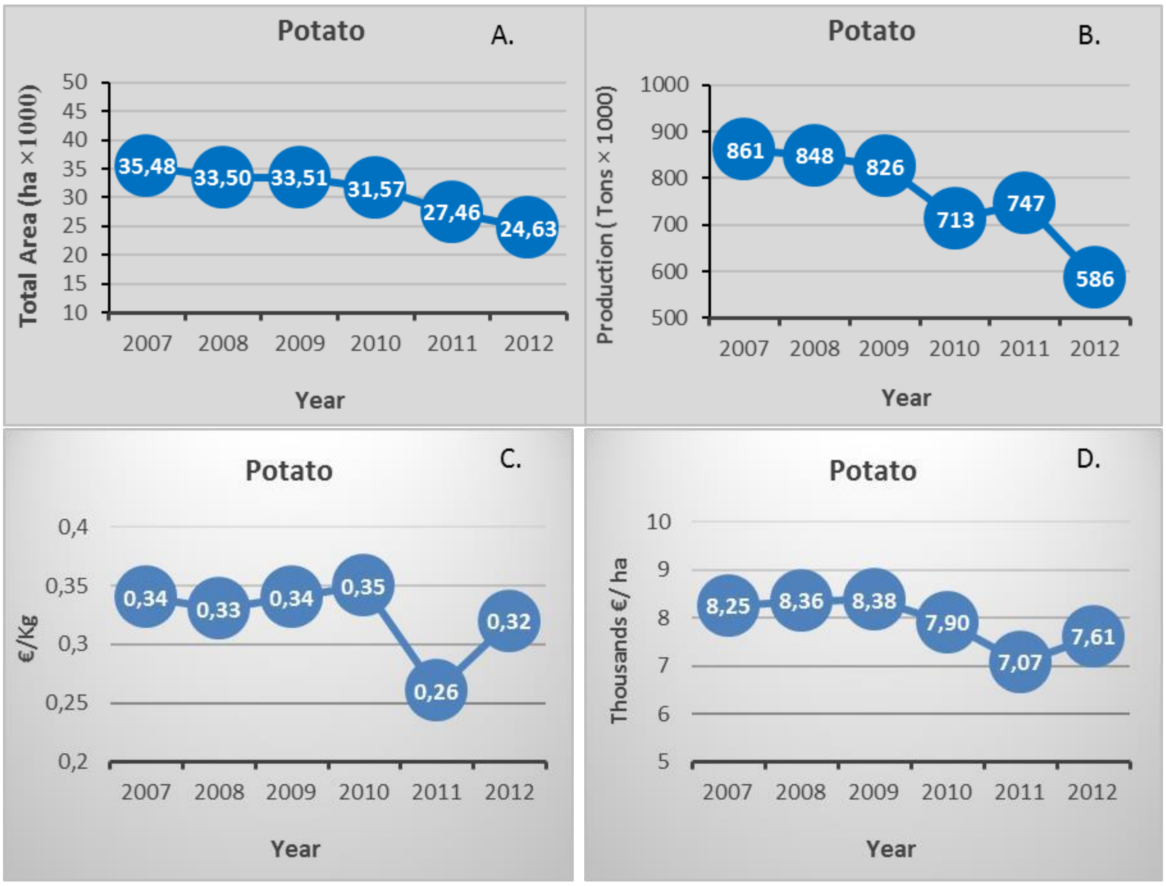


Figure 4 (A-D). Total area (A) and total production (B) of potatoes cultivated in Greece during the years 2007-2012. Mean yearly prices paid to growers for potatoes (C) and mean gross returns (D) during the years 2007-2012 (data from the Greek Ministry of Rural Development and Food).

Today potatoes are grown all over the world and there are many varieties which can be used for many different kinds of uses, such as potatoes for industrial use or baked potatoes making crisps or French fries.

Potato has a biological cycle of about four months. Planting season for potatoes in Greece starts in late November (Messenia, Crete) until mid-August each year. That means that the first harvest starts in mid-April and the last in early December. Therefore, there is an interval of approximately 4 months in which there are no fresh potatoes in the market.

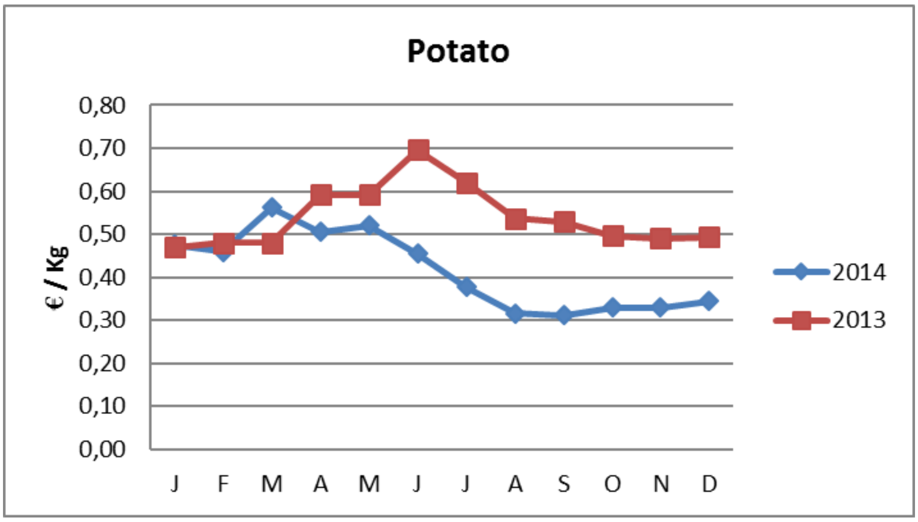


Figure 5. Mean monthly prices for potatoes during the years 2013 and 2014 at the Thessaloniki Central Fresh Fruit and Vegetable Wholesale Market.

Variety selection will be based on the soil and climatic conditions of the cultivation area and the market requirements for specific types of tubers. Main varieties of potato are described below.

Spounta: Medium variety. Large tuber size with elongated shape, shallow eyes and light yellow flesh color. Low resistance to diseases, high resistance to drought and moderate resistance to frost. Tubers with medium dry matter content and good taste.

Lizeta: Medium-early variety. Features are about the same as the previous variety.

Marphona: Medium variety. Large size with spherical tubers, shallow eyes, and light yellow flesh color. Low resistance to diseases, high resistance to drought and low resistance to frost. Tubers with medium dry matter content.

Fampoula: Medium-early variety. Very large size tubers, oval shape, average depth of eyes and light yellow flesh color. Great resistance to viruses and nematodes but low to fungal attacks. Tubers with medium dry matter content.

Agria: Middle-early variety. Large size of tubers, oval shape, elongated shallow eyes and yellow flesh color. Medium-high content of dry matter, high starch content. Moderate resistance to disease, drought and frost.

Potato can grow in a wide range of soils, provided that the soil is well-drained, rich and it contains sufficient amounts of organic matter. In practice, sandy soils, which are heated quickly, are considered to be more suitable for early maturity, high yields and good quality of the tubers . Organic soils with light texture are equally suitable because they show proper drainage and good aeration, which are of great importance for tuberisation, and they favour the absorption of nutrients. The proper soil reaction is slightly acidic with a pH 5,0-6,5 (e.g. in several areas in the prefecture of Messina). However, good yield is achieved in neutral and slightly alkaline soils with pH 6,5-7,5 (e.g. soils in the Florina region). Heavy clay soils with poor drainage should be avoided, because, they favour the production of small size and abnormal tubers. Soils with high moisture levels cause the formation of large freckles on the tubers.

The most important climatic parameters to be considered are: the photoperiod, the temperature and the intensity of solar radiation. The varieties grown in our country show a fairly good adaptability to climatic conditions, achieving high yields under longday conditions and relatively high temperatures. However, tuber production in potato is favored by short days (daytime does not exceed 10 hours) and high intensity of solar radiation (no shading or clouds). The temperature significantly affects the formation and growth of tubers. The potato plant is considered as a cool season plant, with excellent growth at temperatures ranging between 16-21°C. However, the cultivation should be avoided in areas with high incidence of frost. The low temperature during the night may replace the requirements of the plant for low daily temperature and short days, but the very large differences in temperature (e.g. 15°C) between day and night encourage vegetative growth of plants against the production of tubers. Germination of seed tubers is faster when soil temperature is 22°C. At low soil temperature (12°C) the emergence of plants occurs after 30-35 days. High yield is achieved when nighttime and daytime soil temperatures are 12-16°C and 18-20°C, respectively (depending on variety). High soil temperatures (above 20°C) impede tuber formation and tuber growth, which is fully stopped at higher soil temperatures (above 29-30°C). In addition, high soil temperatures cause the formation of tubers with an irregular shape with bulges and the phenomenon of chain tuber (many tubers in the same stolons).

Procedures before planting: normally 2 tons/ha seed tubers are planted. Before planting tubers should be mounted in semi-shadowed places with high humidity and temperature near 20°C to accelerate the onset of sprouting. 7-10 days before planting large tubers should be cut in smaller pieces. 1-2 months prior to planting plowing is necessary and at this time manure is in incorporated into the soil. A few days before planting, milling and the integration of base dressing (recommended 750 kg / ha 11-1515) are necessary. Opening planting rows at a distance of 60-75cm as are the plowshares in a multifilament plow. The row widths used in Greece are from 60 to 75cm. Planting sprouted seed tubers to a depth of 5 to 10 cm depending on the planting season: 5cm if temperature is low and 10cm if temperature is favorable for plant growth. The normal distance between plants within a row should be 20 to 25 cm. After planting, irrigation is applied with small quantities of water. After the emergence of plants irrigation is applied with higher quantities of water . If necessary, Weed killer (Sencor) should be applied 1-2 times applications with. The amount of water given depends on the climate and on the stage of the plant growth. The needs are increased as the plant grows and begins the tuberisation process. Apply 4-5 doses of side dressing (11-15-15 at amount of 750 kg /ha). with irrigation system. When plants reach 20-25cm in height, soil is hilled up around the stem in order to keep the developing tubers completely covered and protect them from exposure to light which leads to the unpleasant phenomenon of tuber greening. Moreover, this cultivation technique favors the formation of more tubers in the plant. Ten days before harvest the following procedures should be applied: First of all irrigation is stopped and then the plants should be defoliated with Reglon in order to facilitate harvesting and maturation of tubers periderm. If potato harvesting machine is not available tubers are pulled out from the ground by hand. Tubers are placed in plastic containers and transported to a warehouse, where they are sorted and packaged in sacks of usually 50 kg. After harvest, potatoes should be stored in the dark in well ventilated areas with, if it is possible, temperatures near to 10°C and humidity near to 80-85%. Yields of potato range from 20-70 tons per ha, but the most common average yield is 30 tons/ha.

1.1.3 Eggplant *(Solanum melongena)*

Eggplant, also known as aubergine, is a warm season vegetable crop with an optimum temperature for production of 22-30 °C during the day and 18/24 ºC during the night. Eggplant is successfully cultivated in sub-tropical and tropical regions and has a higher temperature requirement than tomato and paper, with a higher tolerance to excessively high temperatures and a higher susceptibility to low temperatures. As a field crop, eggplant in Europe is cultivated almost exclusively in Southern Europe. According to data of FAO Statistics (FAOSTAT 2012), Greece ranks in the fourth position in Europe in terms of both total cultivated area and total production of eggplant, following Spain, Italy and Romania. As shown in Figure 6A, the total area of open fields cultivated with eggplant decreased gradually from 2,000 ha to 2,300 ha. At the same time, the total production, which amounted to 44,500 tons in 2008 (Fig. 1B), tended to increase in 2009 and 20010, but thereafter it decreased again to slightly higher levels than those reported for 2008 (47,400 tons in 2011). These figures indicate that the average yield obtained in 2008 from open-field cultivations of eggplant increased in the next years and especially in 2010. Indeed, calculations based on the data of Figure 6 reveal that the average yield of eggplant fruit in open fields, which was 44,500 ton ha^{-1} in 2008, increased to 46,800 in 2009, 51,000 in 2009, then decreased to 47,400 in 2010. This yield level is low and needs to be increased to improve profitability of field-grown eggplant crops. Similarly to tomato, yield increases in field crops of eggplant can be achieved mainly by: a) selecting productive cultivars, b) properly training and supporting the crops and c) shading from mid-June to mid or the end of August to reduce excessive canopy temperatures that may negatively affect fruit setting.

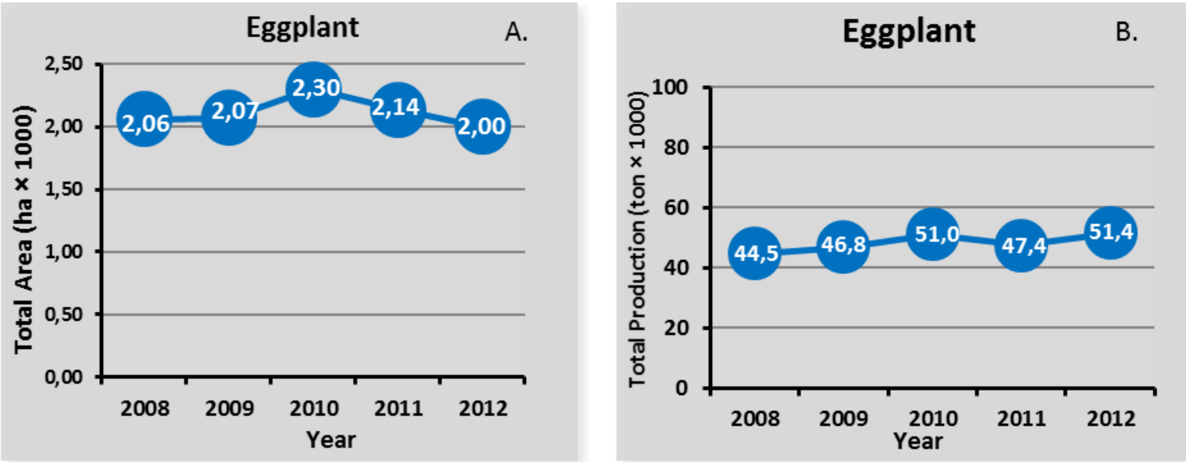


Figure 6 (A-B). Total area (A) and total production (B) of eggplants cultivated in open fields in Greece during the years 2008-2012.

Eggplant needs about 4 to 4.5 months from sowing to the first harvest, depending on the site location of the crop and the exact season of the year, which determine the degree-days. Given this and the high temperature requirements of eggplant, the plants are essentially transplanted in commercial eggplant crops in Greece, as direct seeding in the field would minimize the harvesting period. As a warm-season vegetable with a relatively high susceptibility to sub-optimal temperatures, eggplant intended for field production in Greece has to be sown in February in nurseries and transplanted in March or April, depending on the geographical site, aiming at commencing harvesting by the end of June the earliest. Harvesting in open field lasts up to October and even November in some locations in southern Greek regions. Thus, a harvesting period of over four months can be achieved in some locations with favorable climatic conditions in southern Greece. Therefore, as shown in Table 2, the main center of eggplant cultivation in open fields is Peloponnese with 25.3%, of the total area, followed by Western Greece with 17.2%, where most production is concentrated in the prefecture of Ilia. In these regions, application of mulching and low tunnels is frequent, aiming at early production when the average sales prices are higher than the average prices during the whole open-field growing season (Figure 7). Other important centers of eggplant cultivation in open fields are Central Macedonia with 15.3%, Central Greece with 10.0% and Eastern Macedonia and Thrace with 5.7%, which supply mainly the market during mid and late summer.

Table 2. Cultivated area and production of eggplant in open fields allocated into the 13 regions of Greece in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area (ha)	(%)	Total production (ton)	Mean production (ton/ha)

Eastern Macedonia & Thrace	110	5.7	1,376	12.49
Central Macedonia	297	15.3	5,986	20.18
Western Macedonia	28	1.4	301	10.87
Epirus	99	5.1	1,538	15.50
Thessaly	40	2.1	761	18.91
Ionian Islands	59	3.1	14	0.25
Western Greece	332	17.2	6,000	18.07
Central Greece	193	10.0	4,133	21.41
Attica	87	4.5	190	2.18
Peloponnese	489	25.3	6,425	13.13
North Aegean Islands	39	2.0	665	16.87
South Aegean Islands	59	3.1	365	6.16
	100	5.2		
Total	**1,933**	**100**	**30,024**	
Crete			2,270	22.70 15.53

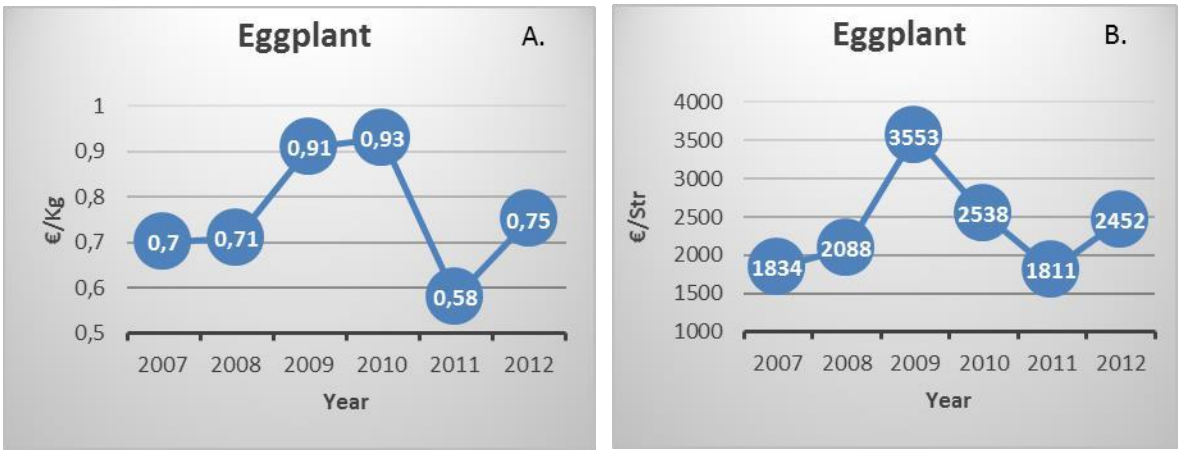


Figure 7 (A-B). Yearly average of the sales price (A) for eggplant and average gross revenues (B) during the years 2007 - 2012 (data from the Greek Ministry of Rural Development and Food).

The yearly average of the sales price for eggplants were equal to or higher than 0.70 € kg^{-1} during 2007-2012, with the exception of 2011, when they decreased to 0.58 € kg^{-1} (Figure 7A). In 2013 and 2014, the sales prices of both long-fruit and oval-fruit type eggplants recorded yearly averages of 1,09 and 1,08 € kg^{-1}, respectively, at the Thessaloniki Central Fresh Fruit and Vegetable Wholesale Market. Nevertheless, the sales price in July and August were half as high as the mean yearly level or even lower. On the other hand, in September, October and November, average prices of 0.70, 0.80 and 0.95 € kg^{-1}, respectively, were recorded for both types of eggplant, which indicates that late-season production can be recommended in site locations with mild climatic conditions. Also in June, average prices ranging from 0.90 to 0.97 € kg^{-1} were recorded, which indicates that early production is recouped. Nevertheless, early production of eggplants relies on the production of seedlings in heated nurseries, and presumably mulching and low covers, which increase the cost, while the high sales prices are offered only for a short time in June. In contrast, late production in autumn relies only on favorable climatic conditions without any heating needs for seedling production or any other special cultural practices. Thus, late open-field production of eggplants in autumn provides currently good opportunities to growers for a reasonably high net income. Nevertheless, any increase in late autumn production of eggplants should keep pace with the limits set by the domestic eggplant consumption to avoid a collapse of prices as long as it is not intended for export.

The imports originate predominantly from Italy and complement the domestic production mainly during the winter, while the exports are directed mostly towards Bulgaria and other neighboring Balkan countries. A substantial increase in exports of eggplant originating from field crops could be achieved by taking advantage of the mild climatic conditions in southern Greece to produce in June and beginning of July, as well as in October and November at low cost. The target market should be mainly the neighboring countries of southeastern Europe, because of the low transportation cost. Exports to northern European countries in those months would also be possible. However, to meet the high quality standards of these markets, production in screenhouses is suggested, to achieve a better control of pests and diseases, and minimize mechanical damage from wind or heavy rain.

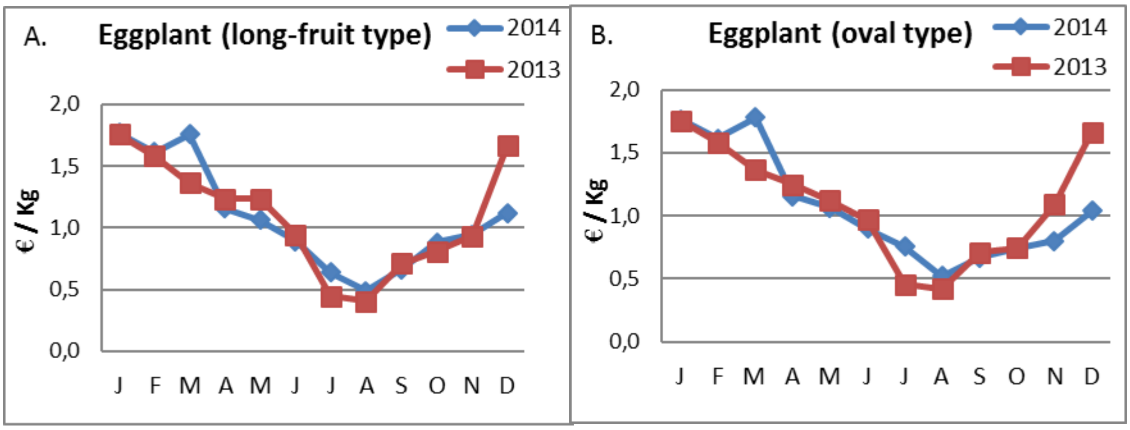


Figure 8 (A-B). Mean monthly prices for long- (A) and oval-fruit (B) types of eggplants during the years 2013 and 2014 at the Thessaloniki Central Fresh Fruit and Vegetable Wholesale Market.

Although the cultivation of eggplant in open fields may start in April and last up to November, the pressure exerted from diseases, insects and other natural enemies in an open field do not allow for such a long cropping period in most cases. Thus, most growers focus either on early production starting harvesting in June and terminating anytime during the summer, when plant protection collapses, or in late production, planting in May or June and starting harvesting in late summer or September.

Considering an average sales price of about 0.60 € kg^{-1} for eggplant fruit, and an average production cost of 0.30 to 0.35 € kg^{-1} in open-field crops yielding about 40 to 50 tons ha^{-1}, an average net income of about 10,000 to 12,000 € ha^{-1} is expected from a field-grown eggplant crop in Greece.

1.1.4 Pepper *(Capsicum annuum)*

Pepper, is a warm season vegetable crop with an optimum temperature for production of 22-28 °C during the day and 16-18 ºC during the night. Pepper is successfully cultivated in temperate and tropical regions and has a lower temperature requirement than eggplant, with a higher susceptibility to low temperatures than tomato. Greece ranks in the fifth position in Europe in terms of both total cultivated area and total production of pepper, following Spain, Holland, Romania and Italy, according to data of FAO Statistics (FAOSTAT 2012). As shown in Figure 9A, the total area of open fields cultivated with pepper increased gradually from 2,950 ha in 2007 to 3,140 ha in 2014. The total production of open fields cultivated with pepper, which amounted to 45,750 tons in 2007 (Fig. 9B) tended to increase in 2009 and stabilized and reached in 2011 to 51,340 tons. Thereafter the production it increased again to slightly upper levels in 2012 to 73,390 tons and decreased again and reached slightly upper levels than those reported for 2011 (55,280 tons in 2014). These figures indicate that the average yield obtained in 2007 from open-field cultivations of pepper increased in the next years and especially in 2012 and decreased again in 2014. However these yield levels are still low and needs to be increased to improve profitability of field-grown pepper crops. Yield increases in field crops of pepper can be achieved mainly by: a) selecting productive cultivars, b) properly training and supporting the crops and c) shading from mid-June to mid or the end of August in order to reduce excessive canopy temperatures that may negatively affect fruit setting.

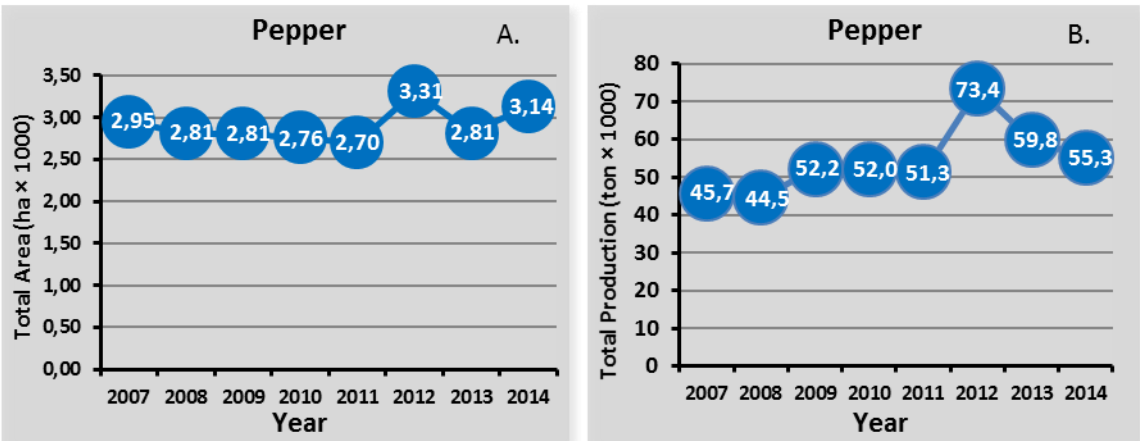


Figure 9 (A-B). Total area (A) and total production (B) of pepper cultivated in open fields in Greece during the years 2007-2014.

Pepper needs about 3 to 5 months from sowing to the first harvest, depending on the variety, the site location of the crop and the exact season of the year, which determine the degree-days. Given this and the high temperature requirements of pepper, the plants are essentially transplanted in commercial pepper crops in Greece, as direct seeding in the field would minimize the harvesting period. Pepper intended for field production in Greece, as a warm-season vegetable with a relatively high susceptibility to sub-optimal temperatures, has to be sown in January to April in nurseries and transplanted after two months in March to May, depending on the geographical site, aiming at commencing harvesting in June. Harvesting in open field lasts up to November in some locations in southern Greek regions. Thus, a harvesting period of over four months can be achieved in some locations with favorable climatic conditions in southern Greece. Therefore, as shown in Table 3, the main center of pepper cultivation in open fields is Thessaly with 18.1%, of the total area, followed by Peloponnese with 9.2%. In these regions, is frequent the application of mulching and low tunnels which aiming at early production when the average sales prices are higher than the average prices during the whole open-field growing season (Figure 10A). Other important centers of eggplant cultivation in open fields are Central Macedonia with 8.7%, Eastern Macedonia and Thrace with 6.8% and Central Greece with 5.2%, which supply mainly the market during mid and late summer.

Table 3. Cultivated area and production of pepper in open fields allocated into the 13 regions of Greece in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area		Total production	Mean production
	(ha)	(%)	(ton)	(ton/ha)
Eastern Macedonia & Thrace	610	19.4	6,795	11.15
Central Macedonia	451	14.4	8,746	19.39
Western Macedonia	152	4.8	1,635	10.78
Epirus	66	2.1	704	10.75
Thessaly	798	25.5	18,068	22.64
Ionian Islands	43	1.4	17	0.39
Western Greece	331	10.6	2,061	6.22
Central Greece	244	7.8	5,247	21.54
Attica	72	2.3	75	1.05
Peloponnese	219	7.0	9,250	42.26
North Aegean Islands	23	0.7	437	19.00
South Aegean Islands	47	1.5	338	7.25
Crete	81	2.6	1,910	23.58
Total	3,135	100	55,284	17.63

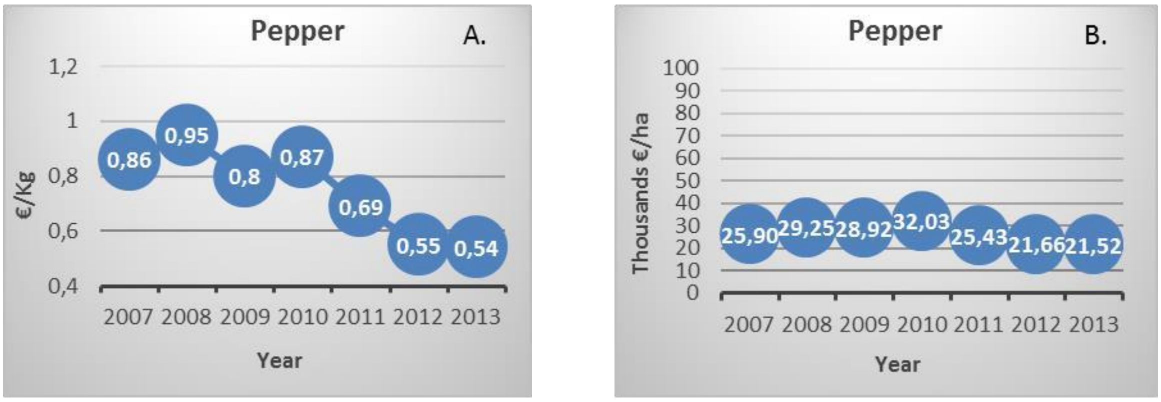


Figure 10 (A-B). Yearly average of the sales price (A) for pepper and average gross revenues (B) during the years 2007 - 2012 (data from the Greek Ministry of Rural Development and Food).

The yearly average of the sales price for pepper were equal to or higher than 0.80 € kg^{-1} during 2007-2010, with the exception of 2011and 2012 when they decreased to 0,69 and 0.55 € kg^{-1} respectively and afterwards stabilized and reached 0,54 € kg^{-1} in 2014 (Figure 10A).

The sales prices of different type of peppers at the Thessaloniki Central Fresh Fruit recorded in 2013 and 2014 yearly averages of 1.09 and 1.01 € kg^{-1} respectively in Sweet Charleston type, while Blocky green type were 1.20 € kg^{-1} in both these two years (Figure 11). The sales price of Florina pepper recorded in 2013 and 2014 yearly averages 1.47 and 1.41 € kg^{-1} respectively, while in Sweet Bell type recorded 1.80 and 1.97 € kg^{-1}. Nevertheless, the sale prices in July, August and September recorded in 2014 in Sweet Charleston type and Blocky green type, were half as high as the mean yearly level or even lower. The sale prices recorded in Florina pepper and Sweet Bell type in the same period were slightly upper level and as high as the mean yearly level respectively. On the other hand average prices of sweet pepper were recorded in October and November of 2014 and were for Sweet Charleston type 0.94 and 0.95 € kg^{1} and for Blocky green type 0.86 and 0.85 € kg^{-1} respectively, which indicates that lateseason production can be recommended in site locations with mild climatic conditions. Also in June, average prices in Florina pepper, in Sweet Bell type and in Sweet Charleston type were recorded ranging from 0.73 to 1.17 € kg^{-1}, which indicates that early production is recouped. Nevertheless, early production of pepper relies on the production of seedlings in heated nurseries, and presumably mulching and low covers, which increase the cost, while the high sales prices are offered only for a short time in June. In contrast, late production in autumn relies only on favorable climatic conditions without any heating needs for seedling production or any other special cultural practices. Thus, late open-field production of pepper in autumn provides currently good opportunities to growers for a reasonably high net income. However, any increase in late autumn production of pepper should keep pace with the limits set by the domestic pepper consumption to avoid a collapse of prices as long as it is not intended for export.

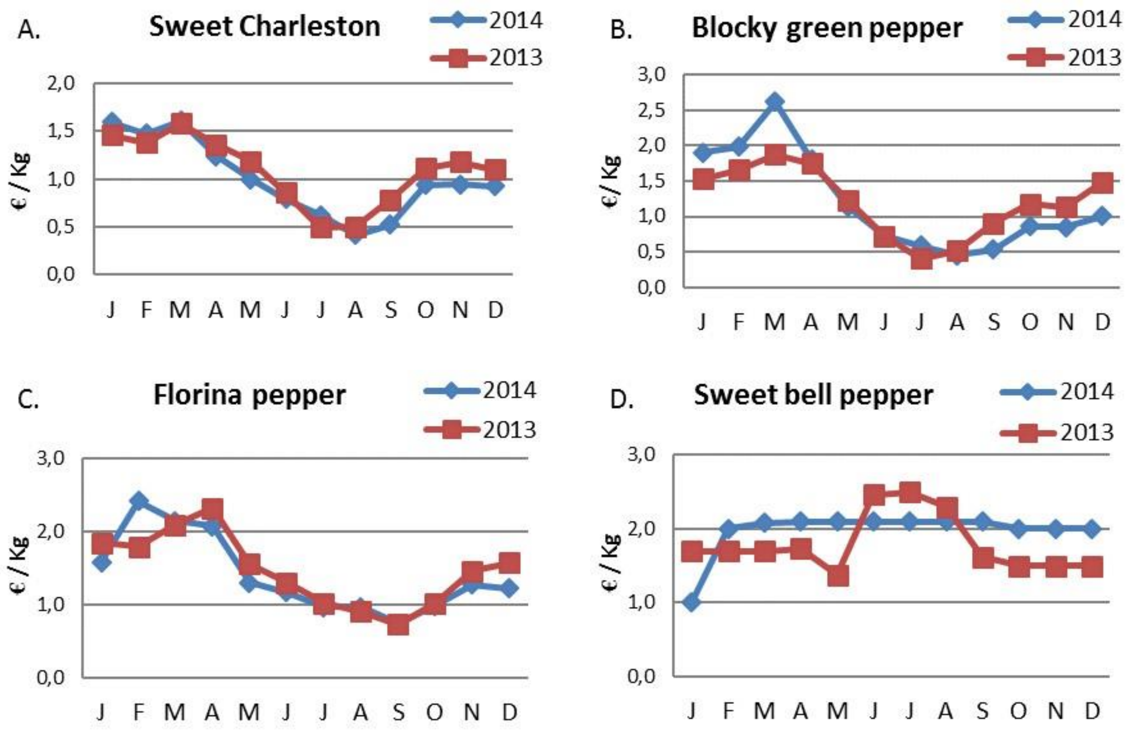


Figure 11 (A-D). Mean monthly prices for different types of pepper: Sweet Charleston (A), Blocky green pepper (B), Florina type (C), Sweet Bell pepper (D) during the years 2013 and 2014 at the Thessaloniki Central Fresh Fruit and Vegetable Wholesale Market.

The imports of pepper originate predominantly from Fyrom, Dutch and Israel, and complement the domestic production mainly during the winter. The imports increased gradually from 7,725 tn in 2003 to 9,695 tn in 2006 and afterwards decreased again and reached lower levels than those reported for 2003 (5,161 tn in 2012) (Table 4). The exports followed different direction and are directed mostly towards Czech, Austria and Bulgaria. The exports increased gradually from 4,984 tn in 2003 to 9,480 in 2006 and from 8,850 tn in 2007 decreased and reached upper levels than those reported for 2003 (5,738 tn in 2011). Afterwards the exports increased again to 9,415 in 2012. A substantial increase in exports of pepper originating from field crops could be achieved by taking advantage of the mild climatic conditions in southern Greece to produce in June and beginning of July, as well as in October and November at low cost. Although the cultivation of pepper in open fields may start in March and last up to November, the pressure exerted from diseases, insects and other natural enemies in an open field do not allow for such a long cropping period in most cases. Thus, most growers focus either on early production starting harvesting in June and terminating anytime during the summer, when plant protection collapses, or in late production, planting in May or June and starting harvesting in late summer or September. The target market should be mainly the neighboring countries of southeastern Europe, because of the low transportation cost. However, exports to northern European countries in those months would also be possible. In order to meet the high quality standards of these markets, production in greenhouses is suggested, to achieve a better control of pests and diseases, and minimize mechanical damage from wind or heavy rain.

Table 4. Imports and exports of pepper in year 2003-2012 in million € and tons, respectively (Greek Ministry of Agriculture).

Year	Imports		Exports	
	Tons	million €	Tons	million €
2003	7,725	6.58	4,984	9.40
2004	8,296	6.84	7,009	11.40
2005	9,428	6.31	7,479	10.38
2006	9,695	7.47	9,480	12.15
2007	7,928	8.73	8,850	13.73
2008	6,031	6.30	7,709	10.12
2009	5,235	5.39	7,556	8.06
2010	4,134	6.24	7,094	8.04
2011	5,364	5.93	5,738	6.77
2012	5,161	5.68	9,415	10.54
Mean	6,900	6.55	7,531	10.06

1.1.5 Cucumber (*Cucumis sativus* L.)

Most of fresh cucumber is produced in greenhouses in Greece. Data about the total cucumber production in Greece allocated into the 13 geographical regions are indicatively shown for one year (2014) in Table5. Comparison of these data with the corresponding data for greenhouse cucumber reveals that the field-grown cucumber crops accounted for nearly one third (36%) of the total area cultivated with cucumber in 2013. However, in terms of production, the cucumber crops in the open field provide only 10% of the total domestic production of cucumber (19,900 ton over a total of 195,000 ton in 2013). This difference is due to the much lower mean yield per hectare obtained in field cucumber crops (24,420 ton ha^{-1} in 2013).

Table 5. Cultivated area and production of cucumber in open fields allocated into the 13 regions of Greece in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area		Total production	Mean production
	(ha)	(%)	(ton)	(ton/ha)
Eastern Macedonia & Thrace	23	2.4	108	4.82
Central Macedonia	62	6.7	853	13.85
Western Macedonia	22	2.4	311	14.01
Epirus	27	3.0	528	19.31
Thessaly	63	6.9	1,382	21.83
Ionian Islands	60	6.5	16	0.26
Western Greece	89	9.7	1,388	15.54

Central Greece	184	20.0	4,848	26.33
Attica	93	10.1	220	2.37
Peloponnese	76	8.3	1,166	15.27
North Aegean Islands	25	2.8	353	13.95
South Aegean Islands	8	0.9	57	6.98
Crete	186	20.2	5,200	27.96
Total	919	100	16,430	17.88

Since cucumber is a warm-season crop, production from the open field comes to the market only in the summer months (from June to September), when the prices are very low. The quality of field cucumber, which is grown as a creeping plant lying on the ground, is lower than that obtained from greenhouse crops and may contain seeds even if gynoecious cultivars are grown due to unwanted pollination. Therefore, only local or traditional cucumber varieties intended for local markets are grown in the field. Thus, field cucumber production is suggested only for selected cultivars, only when a market with special preferences for old-type seeded varieties is available.

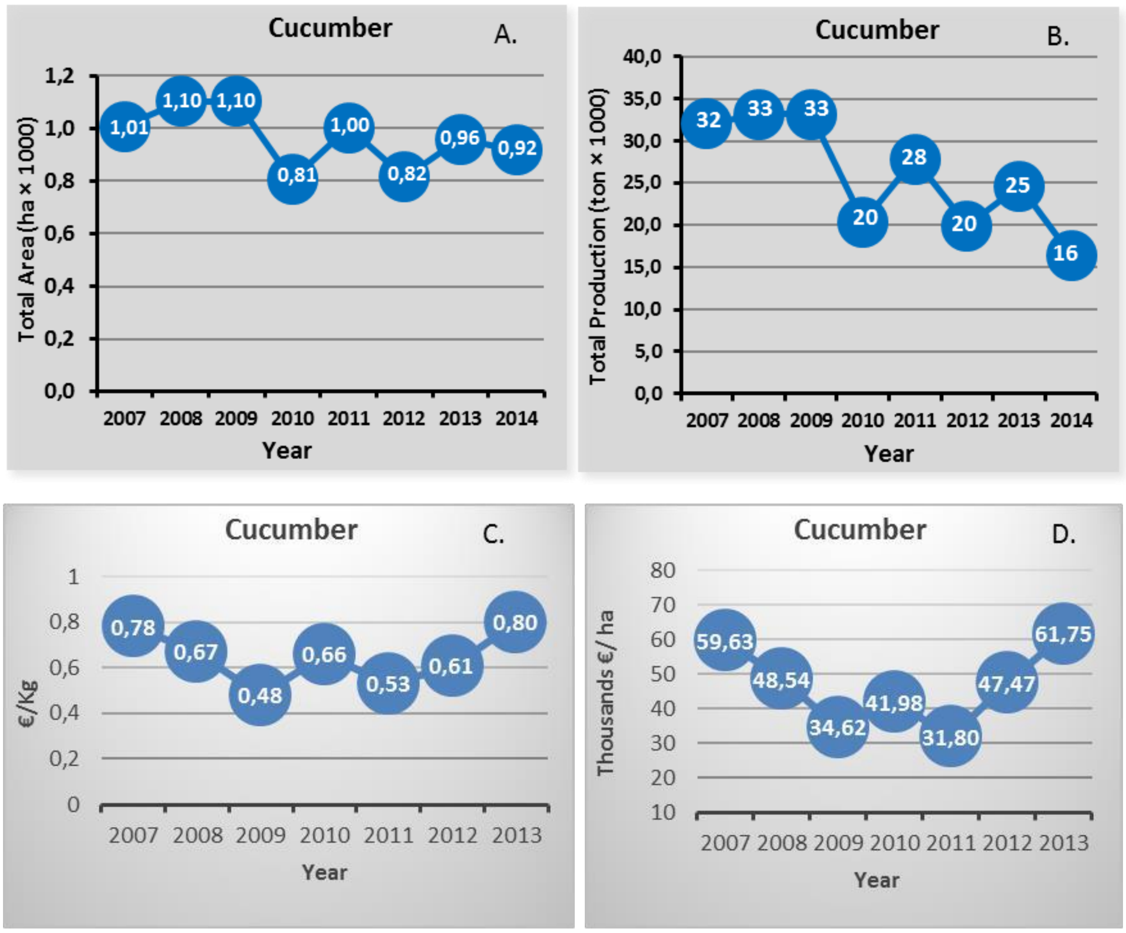
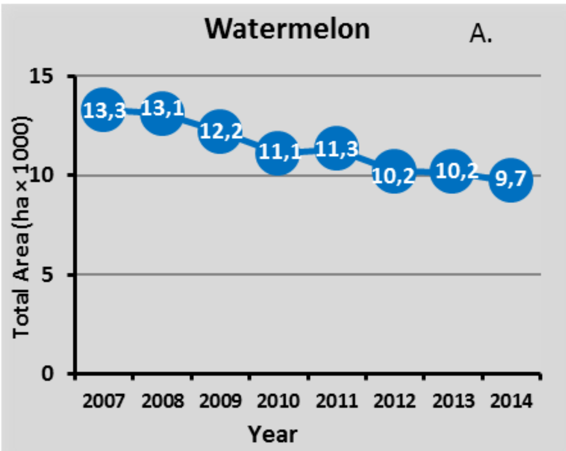


Figure 12 (A-D). Total area (A) and total production (B) of cucumber cultivated in open fields in Greece during the years 2007-2014 and yearly average of the sales price

(C) for cucumber and average gross revenues (D) during the years 2007 - 2013 (data from the Greek Ministry of Rural Development and Food).

1.1.6 Watermelon

Watermelon is a very important crop for Greece due to favorable pedo-climatic conditions in many locations that permit early production in the open field, which is exported. The total area of watermelon grown in the open field in Greece ranged between 9,700 and 13,300 ha during the years 2007 - 2014 (Fig. 13A). The total yearly production obtained from this area ranged from 433,000 to 582,000 tons (Fig. 13B) Nevertheless, one should be aware that the yield of watermelon fruit per ha depends mainly on the duration of the harvesting period. Thus, summer watermelon crops with a longer harvesting period aiming at delivering watermelon to the marked all over the summer provide higher yields that early watermelon crops aiming at producing watermelon just for a short period at the beginning of the season, when the prices are very high.



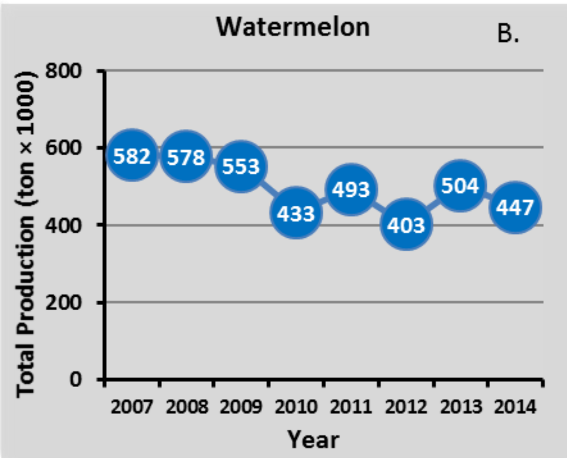


Figure 13 (A-B). Total area (A) and total production (B) of watermelon cultivated in open fields in Greece during the years 2007-2014.

As can be concluded by the geographical distribution of watermelon cultivation in open fields, which is shown indicatively for 2013 in Table 6, the leading region in field watermelon cultivation is Central Greece. Actually, most of watermelon production in open fields (>50%) originates from Prefecture of Ilia, which provides optimal conditions for early production.

Weighted average sales price for watermelon during the years 2007 - 2012 according to data of the Greek Ministry of Rural Development and Food (MRDF) are shown in Figure 14A. The mean price over the six years amounted to 0.25 € kg^{-1}. This price is low and leaves a very short profit margin to growers. Moreover, watermelon prices tended to decrease from 2009 to 2012, presumably due to the economic crisis. However, this price is an average for the whole season of the year. When considering the monthly evolution of the prices during a year, which is shown indicatively for 2013 and 2014 in Figure 15, it becomes clear that much higher price levels for watermelon, are achieved during April, May and June. The early production of watermelon in Greece starts in May 20 to May 25 May, particularly in the prefectures of Ilia, Messinia as well as in Crete. Early production at these sites is achieved by planting by the end of February or by the first week of March using mulching (black-white plastic sheets) and low tunnels. The tunnels are removed in April and subsequently the plants grow in fully open fields lying on the ground without support, covering the whole cultivated area. These crops are aimed at producing early watermelon for only a short period of about one month and subsequently the fields are used for the cultivation of zucchini.

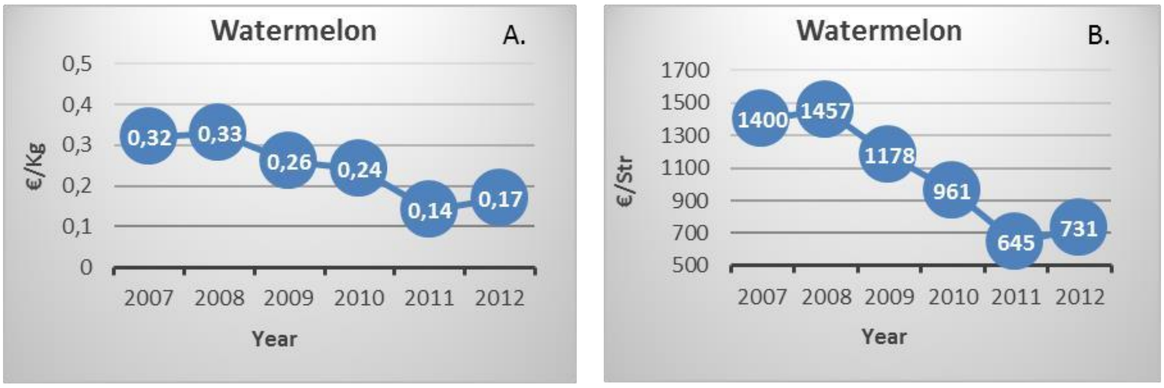


Figure 14 (A-B). Weighted average sales price for watermelon during the years 2007 - 2012, and mean gross revenues per cultivated area unit during the years 2007 - 2012 (data from the Greek Ministry of Rural Development and Food).

Table 6. Cultivated area and production of watermelon in open fields allocated into the 13 regions of Greece in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area (ha)	(%)	Total production (ton)	Mean production (ton/ha)
Eastern Macedonia & Thrace	656	6.8	8,031	12.23
Central Macedonia	1,045	10.8	55,737	53.31
Western Macedonia	58	0.6	1,255	21.69
Epirus	210	2.2	6,832	32.61
Thessaly	529	5.4	22,486	42.54
Ionian Islands	43	0.4	41	0.95
Western Greece	4,960	51.1	274,000	55.24
Central Greece	714	7.4	32,608	45.64
Attica	28	0.3	200	7.16
Peloponnese	285	2.9	9,355	32.80
North Aegean Islands	193	2.0	16,140	83.63
South Aegean Islands	406	4.2	3,069	7.56

	577	6.0		
Total	9,705	100	447,377	
Crete			17,623	30.52
				46.10

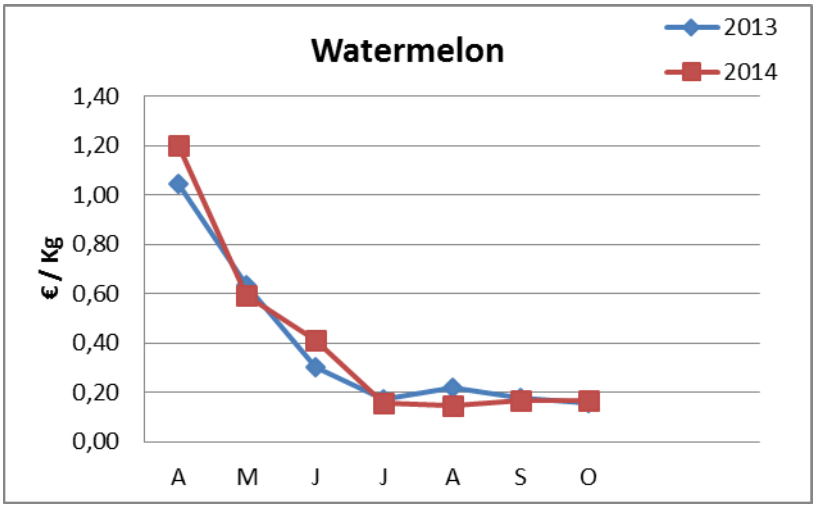


Figure 15. Mean monthly prices for watermelon during the years 2013 and 2014 at the Thessaloniki Central Fresh Fruit and Vegetable Wholesale Market.

As shown in Figure 15, the average sales price during the end of May and the first two weeks of June are double as high as the summer prices and thus they can recoup the higher cost generated by the application of mulching and low tunnel, leaving also a higher economic benefit to the growers. However, the objective of producing early watermelon is not only to sell at higher prices in the domestic market but mainly to export, thereby selling at even higher prices. As shown in Table 7, the Greek exports of watermelon amounted roughly to 150,000 - 200,000 tons year^{-1} in the last ten years, which corresponds to nearly one third of the total domestic production. Greece also imports watermelon but the imported amounts (about 1,000 to 3,000 tons year^{-1}) correspond to about 2% of the exports. Nevertheless, in terms of value, the imports correspond to about 3% of the exports, because they take place mainly out of season (winter to early spring), when the watermelon prices per kilogram are higher than those achieved in the export, which take place mainly in May and June.

Watermelon is almost exclusively a transplanted crop in Greece. Due to the intensive character of early watermelon production in Greece and the limited available area, crop rotation is rarely applied in these fields. Soil fumigation is not an option in these fields due to both high cost and lack of efficient fumigants. Therefore, to protect the crop against soil-borne diseases and nematodes and especially against *Fusarium*, watermelon in Greece is routinely grafted onto rootstocks belonging to other Cucurbitaceae species. Nearly 95% of the total area cultivated with watermelon in Greece is planted using grafted transplants.

Table 7. Imports and exports of watermelon in year 2003-2012 in million € and tons, respectively (Greek Ministry of Agriculture).

Year	Imports		Exports	
	Tons	million €	Tons	million €
2003	6,144	2.34	124,875	40.12
2004	3,490	1.19	156,589	32.73
2005	2,829	1.07	167,896	29.11
2006	8,491	2.06	183,078	49.32
2007	4,654	1.99	167,607	37.75
2008	3,198	1.80	183,496	48.12
2009	1,357	0.68	166,823	40.26
2010	3,143	1.39	210,913	51.39
2011	1,040	0.61	135,859	27.73
2012	2,666	0.90	153,833	36.43
Mean	3,701	1.40	165,096	39.30

Taking into consideration the above referenced data and information, it can be concluded that early watermelon is a promising field crop for southern Greece and especially for Peloponnese and Crete, mainly because it provides good prospects for exports. To maintain and even increase market shares of Greek watermelon in export, selection of new cultivars that are popular in the target markets of Europe is needed, based on screening for appropriate fruit size, seedless flesh, and sweetness. In addition, screening should focus also on fruit resistant to transportation, as well as on selection of appropriate rootstock/scion combinations providing resistance to soil-borne pathogens and high yields without compromising the quality and especially the flavor.

1.1.7 Melon *(Cucumis melo)*

Melon is an important fruit vegetable for Greece. Most melon fruit is produced in open fields in Greece but the cultivated area tended to decrease since 2009. As shown in Figure 16A the total area of open fields cultivated with melon amounted to 6,800 ha in 2007-2009 but decreased to 5,700 ha in 2010 and 3,600 ha in 2012. Nevertheless, during the last two years, a slight increasing tendency was observed in the total openfield area cultivated with melon, which resulted in a level of 4,100 ha in 2014. The total production of melon in open fields increased slightly from 149 tons in 2007 to 161 tons in 2009, but thereafter a strong decreasing tendency was recorded which ended up to a yearly production of only 66 tons in 2014, which corresponds to only 41% of that obtained in 2009 (Figure 16B).

Most of melon production is concentrated in a few regions, particularly Western Greece with 19.6%, Central Greece with 19.4%, Thessaly with12.6%, and Peloponnese with 10.1% (Table 8). Western Greece (mainly the regional units of Ilia and Achaia), Peloponnese (mainly the province Trifylia in Messenia) and Crete produce early melon starting from the end of May aiming at premium prices while Central Greece, Thessaly and most other regions produce melon mainly for the standard summer season.

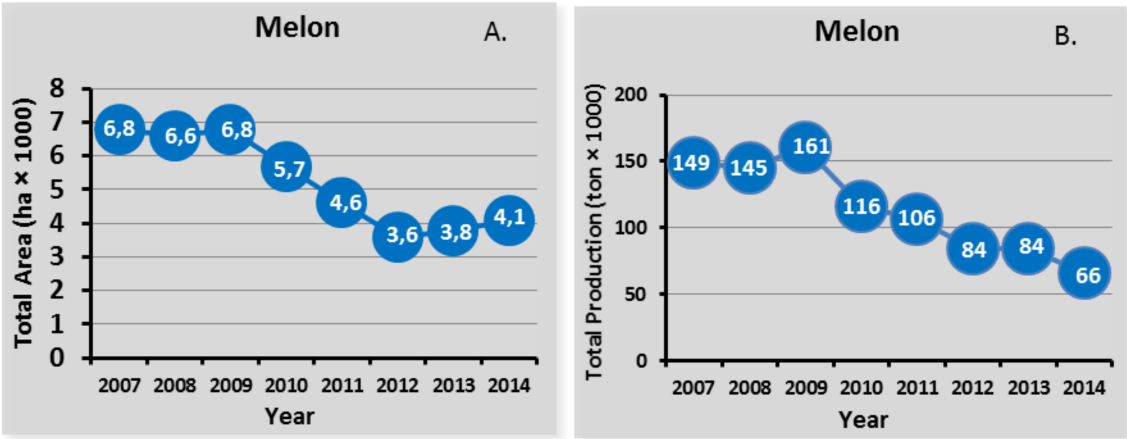


Figure 16 (A-B). Total area (A) and total production (B) of melon cultivated in open fields in Greece during the years 2007-2014.

Table 8. Cultivated area and production of melon in open fields allocated into the 13 regions of Greece in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area (ha)	(%)	Total production (ton)	Mean production (ton/ha)
Eastern Macedonia & Thrace	396	9.7	1,781	4.50
Central Macedonia	402	9.8	7,643	19.00
Western Macedonia	61	1.5	742	12.26
Epirus	70	1.7	1,334	19.05
Thessaly	514	12.6	6,640	12.93
Ionian Islands	65	1.6	63	0.98
Western Greece	801	19.6	15,800	19.72
Central Greece	794	19.4	18,435	23.22
Attica	101	2.5	180	1.79
Peloponnese	411	10.1	2,713	6.60
North Aegean Islands	81	2.0	2,743	34.07
South Aegean Islands	116	2.8	610	5.28
Crete	278	6.8	7,550	27.21
Total	4,087	100	66,234	16.21

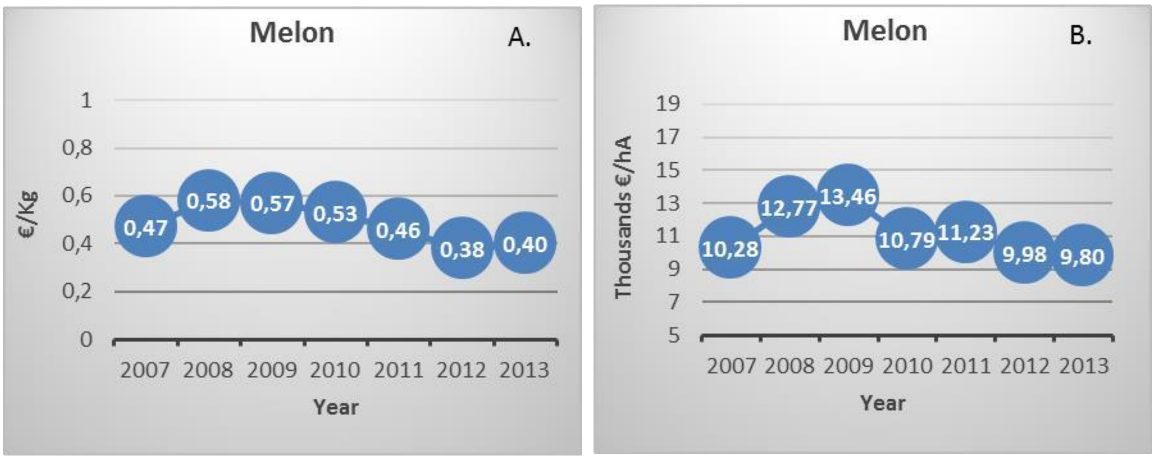


Figure 17(A-B). Weighted average sales price for melon during the years 2007 - 2013, and mean gross revenues per cultivated area unit during the years 2007 - 2013 (data from the Greek Ministry of Rural Development and Food).

The yearly average of the sales price for the grower showed a small increasing tendency in the years between 2007 and 2010 (from 0.47 to 0.53 € kg^{-1}, respectively), followed by a stronger decrease to 0.38 and 0.40 € kg^{-1} in 2012 and 2013, respectively (Figure 17A). This decrease in prices after 2010, despite the strong decrease in production, was presumably a result of the economic crisis that affected the country during these years.

The imports of melon were very low and more or less stable around 1,620 tons in the years 2003-2011, while in 2012 the imports were decreased almost to 50% when compared to 2011 (Table 9). With respect to the exports, these were high in 2003. However, in 2004 and afterwards a sharp decrease up to 80-90% was observed in melon exports leading to more or less stable and relatively very low amounts until 2012. It seems that by 2004 an abrupt loss in competitiveness was observed in the Greek melon production, presumably because other neighboring countries (Turkey, Israel) managed to increase their exports. Currently, the melon produced in Greece is not considered an important commodity for the export. This seems to be the reason, together with the economic crisis which reduced the domestic consumption, for the sharp reduction of melon production in open field in the last five years. However, given the favorable pedo-climatic conditions of the country, melon production might recover in the next years if the export is better organized and better cultivars are selected.

Table 9. Imports and exports of melon in year 2003-2012 in million € and tons, respectively (Greek Ministry of Agriculture).

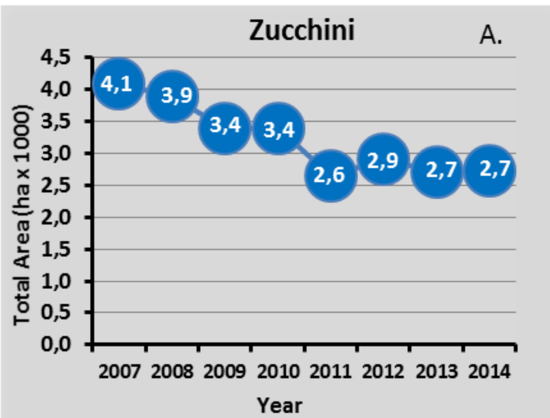
Year	Imports		Exports	
	Tons	million €	Tons	million €
2003	1,724	1.70	21,962	6.43
2004	2520	1.73	1,580	0.38
2005	1,221	1.20	4,185	1.23
2006	1,570	1.61	2,263	0.49

2007	1,980	1.92	7,048	1.06
2008	1,563	1.66	1,772	0.42
2009	2,231	2.19	3,014	1.35
2010	1,324	1.36	2,481	0.81
2011	1,349	1.14	5,724	2.01
2012	741	0.81	3,557	0.92
Mean	1,622	1.53	5,359	1.51

Melon is almost exclusively a transplanted crop in Greece. About 20% of the total area cultivated with melon in Greece is planted using grafted transplants. Melon is a vegetable species in which grafting is performed intensively to control soilborne diseases and improve yield and tolerance to environmental stresses. Generally, melons are grafted onto the same species (*C. melo* L.) and very rarely onto pumpkin (*Cucurbit*a spp., *Cucurbita moschata* × *Cucurbita maxima* hybrids) and white gourd (*Benincasa hispida*) rootstocks. However, in these cases, the taste and the fruit shape may be often negatively affected by grafting, indicating that metabolites associated with fruit quality are translocated to the scion through the xylem. This decrease in fruit quality does not represent a general phenomenon but depends on the specific scion-rootstock interaction and on the response of the particular combination to the climatic conditions and cultural practices. In order to increase the exports of this product up to the levels of 2003, it is extremely necessary to identify rootstocks and rootstock/scion combinations with positive impact on fruit quality especially on the health-promoting compounds and flavor. One of the prerequisites for early melon to become again a promising field crop for exports in Greece is to increase the quality of fruit obtained from grafted plants.

1.1.8 Zucchini ((*Cucurbita pepo* L.),

Zucchini known also as summer squash, is an important fruit vegetable for Greece. Most zucchini fruit is produced in open fields in Greece but the cultivated area tended to decrease since 2009. As shown in Figure 18A, the total area of open fields cultivated with zucchini amounted to 4,100 ha in 2007 but decreased to 3,400 ha in 2009 and 2.911 in 2014. Most of zucchini production is concentrated in a few regions, particularly Peloponnese with 18.3%, Western Greece with 15.0%, Central Macedonia with 14.2%, and Central Greece with 10.6 (Table 10).



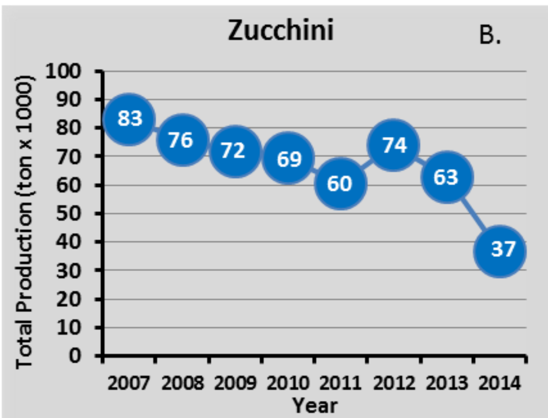


Figure 18 (A-B). Total area (A) and total production (B) of zucchini cultivated in open fields in Greece during the years 2007-2014.

Table 10. Cultivated area and production of zucchini in open fields allocated into the 13 regions of Greece in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area (ha)	(%)	Total production (ton)	Mean production (ton/ha)
Eastern Macedonia & Thrace	114	4.2	549	4.82
Central Macedonia	389	14.2	5,105	13.11
Western Macedonia	31	1.1	328	10.73
Epirus	128	4.7	2,185	17.10
Thessaly	107	3.9	1,977	18.50
Ionian Islands	144	5.3	52	0.36
Western Greece	410	15.0	6,480	15.80
Central Greece	290	10.6	5,778	19.94
Attica	245	9.0	250	1.02
Peloponnese	502	18.3	8,487	16.92
North Aegean Islands	29	1.0	832	29.19
South Aegean Islands	63	2.3	358	5.71
Crete	287	10.5	4,440	15.47
Total	2,911	100	36,820	13.45

The total production of zucchini in open fields also decreased in 2008, 2009, and 2010, in comparison with 2007, but thereafter a strong increasing tendency was observed, which resulted in a similar production level in 2012 with that recorded in 2007 (Figure 18B).

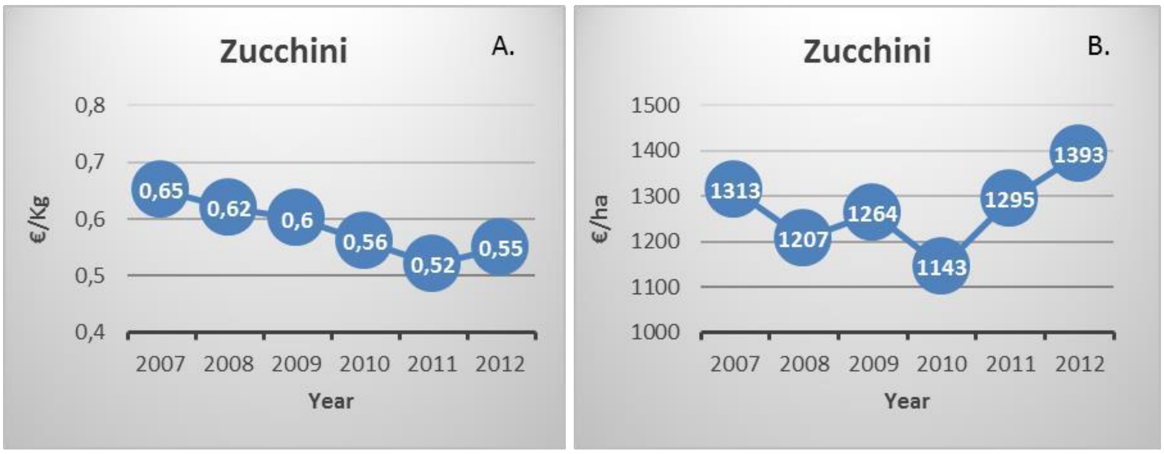


Figure 19 (A-B). Yearly average of the sales price (A) for zucchini, and average gross revenues (B) , during the years 2007 - 2012 (data from the Greek Ministry of Rural Development and Food).

The yearly average of the sales price for the grower showed a small decreasing tendency in the years between 2007 and 2011 (from 0.65 to 0.52 € kg^{-1}, respectively), followed by a small recovery to 0.55 € kg^{-1} in 2012 (Figure 19A) and a stronger increase to 0.81 and 0.77 € kg^{-1} in 2013 and 2014, respectively (Figure 20). At the same time, the imports and exports of zucchini in Greece were more or less stable and relatively low (Table 11), and thus their impact on the evolution of the cultivated area and the sales prices was rather insignificant. Actually, the imports covered consumption needs for short-periods, when the out of season zucchini production was not high enough to fully cover the domestic demand.

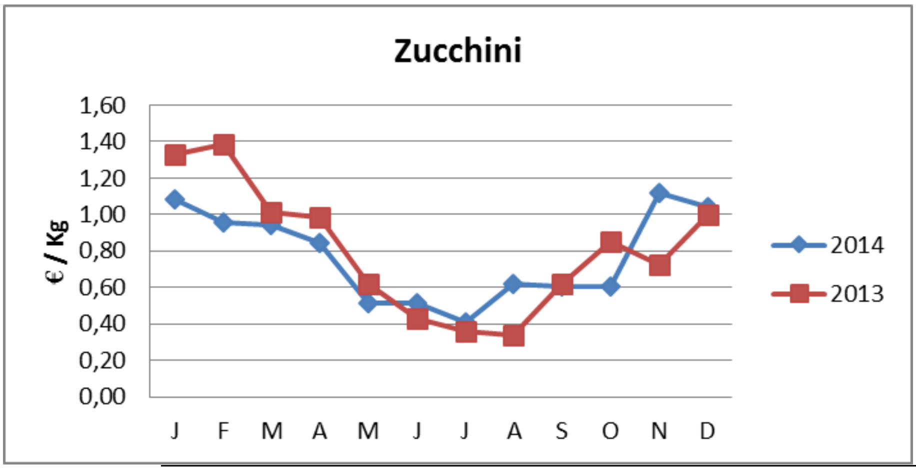


Figure 20. Mean monthly prices for zucchini during the years 2013 and 2014 at the Thessaloniki Central Fresh Fruit and Vegetable Wholesale Market.

Table 11. Imports and exports of zucchini in year 2003-2012 in million € and tons, respectively (Greek Ministry of Agriculture).

Year	Imports		Exports	
	Tons	million €	Tons	million €
2003	4,735	2.65	23,775	28.22
2004	5,809	2.71	23,087	19.49
2005	2,596	2.09	20,170	25.31
2006	2,301	1.80	24,473	25.08
2007	1,784	2.12	21,697	20.20
2008	1,526	1.59	20,742	18.17
2009	899	1.26	17,564	21.28

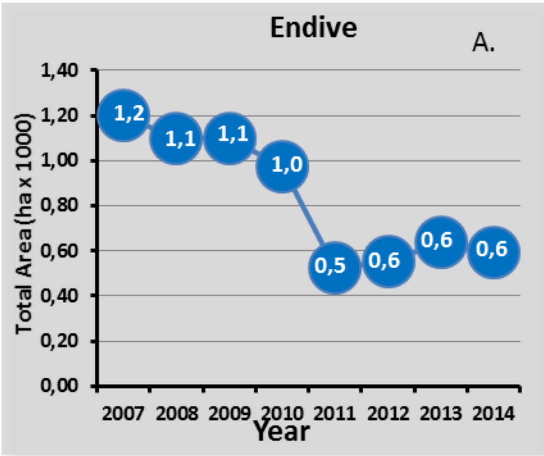
2010	689	0.73	29,354	28.49
2011	523	0.58	26,178	19.32
2012	485	0.50	30,668	29.16
Mean	2,135	1.60	23,771	23.47

Zucchini is a warm-season crop with a high susceptibility to frost. As a rule, zucchini in Greece is a transplanted crop, especially when the cultivation is established in spring. When planted in spring, duration of 35-40 days is needed from planting to the first harvest. Mulching and low tunnels enable an earlier planting and a shorter growing period up to the first harvest. Thus, harvesting field-grown zucchini in Greece can commence by mid or even beginning of May. In lowlands with mild climate in southern Greece, production of zucchini can continue up to November. As shown in Figure 20, especially the late crops that produce zucchini in October and November are the most profitable for the growers, because the sales prices are higher during these months. Relatively satisfactory prices are achieved also in May and September. In contrast, the selling prices in the summer months are very low. Zucchini is not supported and the plant density is low, which means that the cost for purchasing transplants is also low. Cultural practices, that may raise the production cost are mainly restricted to disease, insect and weed control, as well as manual harvesting. Considering a mean price of about 0.60 € kg^{-1} and taking into consideration that the cost of open-field zucchini production is estimated to range from 0.30 to 0.35 € kg^{-1}, for a total yield of 25 to 30 tons ha^{-1}, an average net income of about 8,000 to 10,000 € ha^{-1} is expected from a field-grown zucchini crop in Greece.

1.1.9 Endive *(Cichorium endivia)*

Endive basically originates from Mediterranean countries and eastern India. It is mainly grown in Attica and Thessaloniki. The biological cycle of endive is about 70120 days. There are two types of endive a) crispa and b) ladifolia. In the first category the main varieties are: Green Curled Ruffic and Salad King. In the second category the main varieties are: Full Heart Batavian, Florida Deep Heart και Meaux Curled.

Endive usually grows well in a fertile (45-60 cm depth) well-drained soil, rich in organic matter. Also it grows well in neutral or slightly acid soils (pH 6.0-7.0). It is a cold season plant with optimal growth temperatures 15-18°C. Ploughing and milling is required for land leveling. Also a base dressing is necessary (recommended 500kg/ha 21-0-0 + 300-400kg 0-48-0 and 0-0-48) and digested manure (if available 20-40 tons/ha). Sowing is performed in lines of 30-45 cm × 25-35 cm. Required amount of seed is 4000-5000 g/ha. Irrigation is applied by the method of artificial rain or via a drip system. Apply one or more doses of side dressing: ammonium nitrate at 80-100 kg/ha. The harvest begins in the autumn and continues until late spring. The plants are cut by hand, washed and placed in cardboard or plastic crates for transport to the market. Long term storage conditions for endive are 0°C and 95% humidity. Average yield of endive is about 30 tons/ha.



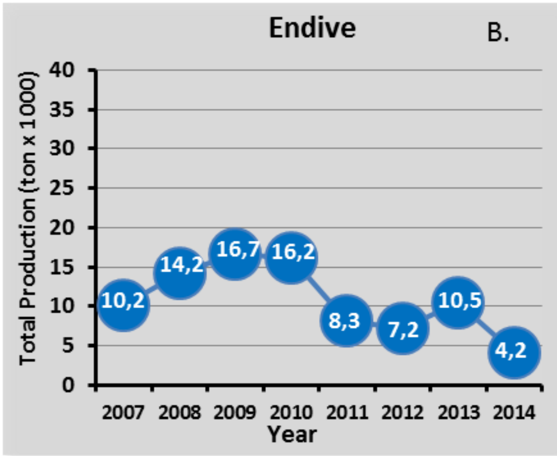


Figure 21 (A-B). Total area (A) and total production (B) of endive cultivated in Greece during the years 2007-2014.

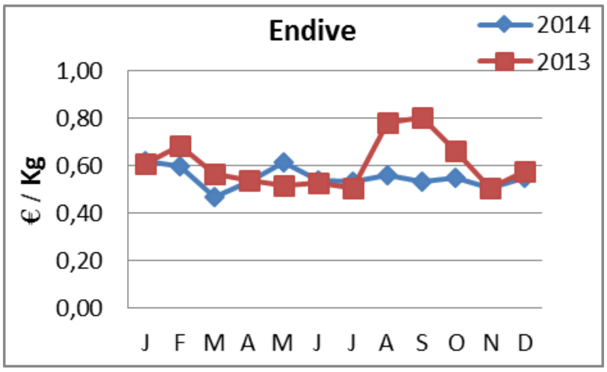


Figure 22. Mean monthly prices for endive during the years 2013 and 2014 at the Thessaloniki Central Fresh Fruit and Vegetable Wholesale Market.

1.1.10 Chicory Leafy chicory, non-witloof (*Cichorium intybus*)

Chicory basically originates from Mediterranean countries. It is mainly grown around major urban centers. In Greece, several varieties of radish are cultivated, with differences in color and shape of leaves. Domesticated chicory has a sweet taste while Italian chicory is more bitter e and there are also various other types such as wild chicory, wild red and white wild.

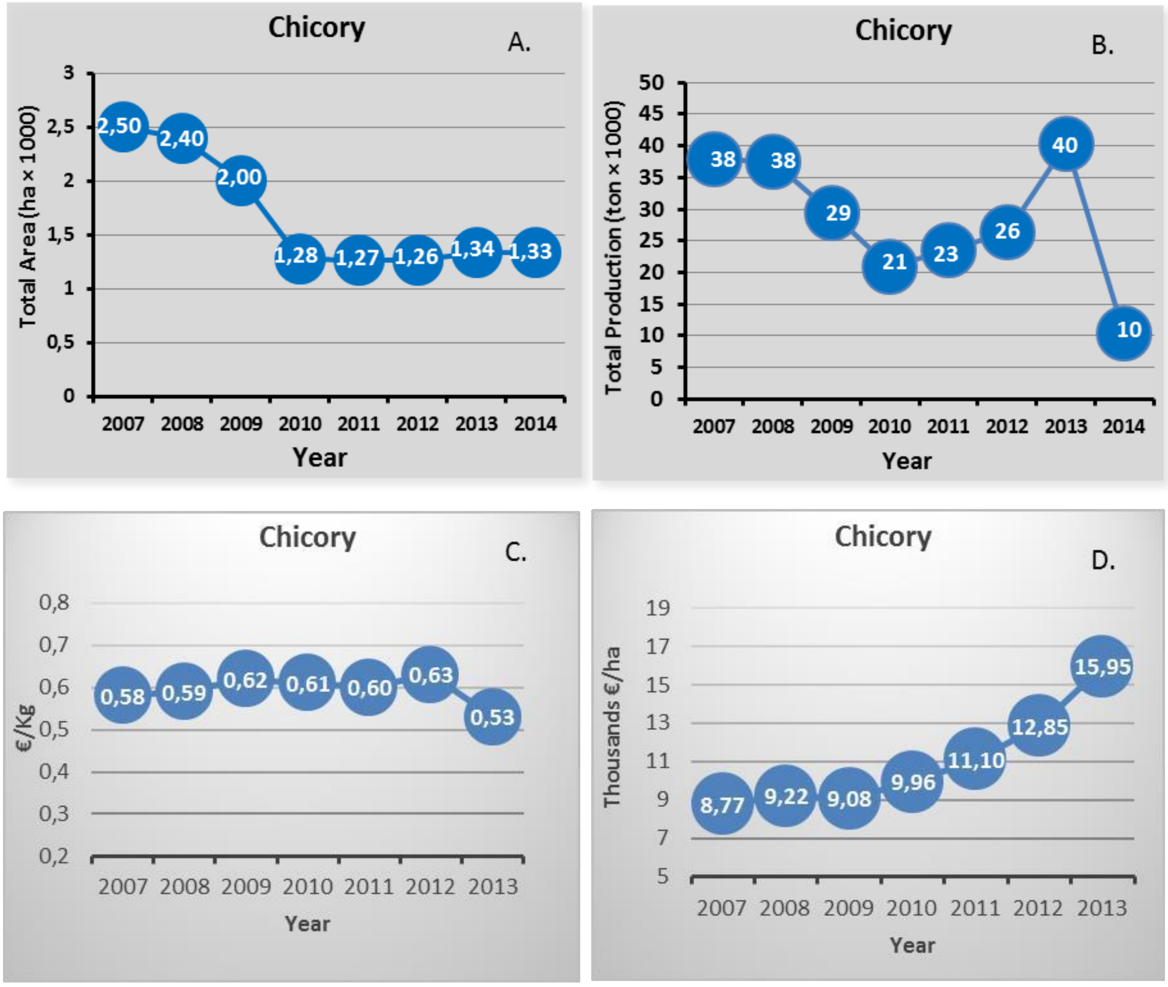


Figure 23 (A-D). Total area (A) and total production (B) of chicory cultivated in Greece during the years 2007-2014 and yearly average of the sales price (C) for chicory and average gross revenues (D), during the years 2007 - 2013 (data from the Greek Ministry of Rural Development and Food).

The last 5 years, the area cultivated with chicory in Greece has gradually reduced. However, total production has not seriously decreased, as higher yields are attained and income has risen over the years, doubling per hectare twice from 2007 to 2013.

Chicory grows well in a variety of slightly acidic soils (pH = 6.0-6.5). It is a cold season plant and is resistant to low temperatures. Procedures before planting: ploughing and milling is required for land leveling. Also the integration of a base dressing is necessary (recommended 500 kg/ha 21-0-0 + 300-400 kg 0-48-0 and 0-0-48) and digested manure (if available 20-40 tns /ha.). Procedures after planting: sowing is performed in lines of 30-45 cm x25-35 cm. Required amount of seed is 4-5 kg/ha.

Irrigation applied by the method of artificial rain. Apply one or more doses of side dressing: ammonium nitrate at an amount of about 80-100 kg/ha. Harvesting begins when the leaves acquire a length of 15-20 cm; in total 4-5 harvests. The plants are cut by hand and then they are cleaned and placed in cardboard or plastic crates for transport to the market. Storage conditions for chicory: 0°C with 95% humidity. Average yield of chicory is 25-30 tons/ha.

1.1.11 Wild edible vegetables

Wild edible vegetables are a large class of wild plant species which are traditionally collected and consumed for many years. During the last few years, some of these plants have been systematically cultivated, with good yields, good prices and. These plants have an excellent nutritional value, excellent flavor and they are eaten raw or cooked. Because of the increasing demand for Mediterranean diet products, there are excellent prospects for further spread of the cultivation of these plants. A typical example of wild edible vegetable which is systematically cultivated is stamnagathi and this will be further described.

Stamnagathi *(Cichorium Spinosum)*

Stamnagathi is a wild plant and is grown in southern Europe, particularly in coastal areas with mild winters. In Greece, it is grown in Central, Islands and Southern Greece.It has exceptional organoleptic characteristics and high nutritional value that has been validated by many studies both in Greece and in Sicily. It is cultivated mainly in Crete and in Attica, where it is grown in organic or inorganic farming conditions.

Stamnagathi grows well in a variety of soils. Although soil salinity has a negative influence on plants productivity, according to the research that has been carried out at the Laboratory of Vegetable Crops in Agricultural University of Athens, the plant has shown very high resistance to salinity. It needs, as indicated by its geographical spread, mild winters to its biological cycle, and it can grow as a perennial. However, when the plant is cultivated as an annual it can be grown throughout Greece if the time of sowing allows plants growth during a period without low temperatures.

Procedures prior to sowing:

1-2 months before sowing, light plowing and incorporation of manure thoroughly digested (20tons / ha) and base dressing (500-1000 kg/ ha. 11-15-15 depending on soil fertility) are necessary. A milling few days before sowing. Sowing is performed in rows or across the soil surface. Note that the linear sowing (30x15 cm.) facilitates weed control with shallow hoeing.

Procedures following sowing:

Irrigation is applied with low sprinklers. Caution! Quantities of water should be evenly distributed and in quantities that do not cause soil saturation with water. Rarely a small amount of ammonium nitrate at 100 kg / ha will be needed as side dressing. Harvesting begins when the diameter of the rosette has reached the commercial size of 10 to 15 cm.. Plants are harvested by hand, and then, washed with cold water and packaged in sealed plastic bags to prevent water loss. They are stored for 6-7 days at 2ºC. Average yield of stamnagathi reach about 10-20 tons / ha.

1.1.12 Cabbage

Cabbage is an important crop throughout the world, especially in the temperate regions. In Europe, it is mainly cultivated and consumed in the northern countries (e.g. Poland, Romania, Germany and England); however, it is popular in Mediterranean counties as well. There are three types of cabbage, namely, white or white-green, red and the "savoy" type with crinkled leaves (which is not popular in Greece).

The last decade the cultivated area with cabbage in Greece is gradually reduced, from 79,000 ha in 2007 to 56,400 ha. in 2013 (Fig 24A). However, total production was not seriously decreased, as higher yields are attained, due to the use of improved varieties and cultural practices, which in combination with the rather stable retail prices per kg of produce, led to an increase of the farmers prices from 2010 onwards (Fig. 24B,D). Despite the relatively reduced production in Greece during the last few years, our country is self-sufficient in cabbage, since exports are increased (from 673 tons in 2003 to 2,521 tons in 2012) and imports are decreased (from 3,854 tons in 2003 to 851 tons in 2012). Cabbage main cultivation regions in Greece are the island of Euboia (approximately 20% of Greek production in 2008), followed by the prefectures of Thessaloniki, Argolis and Attica.

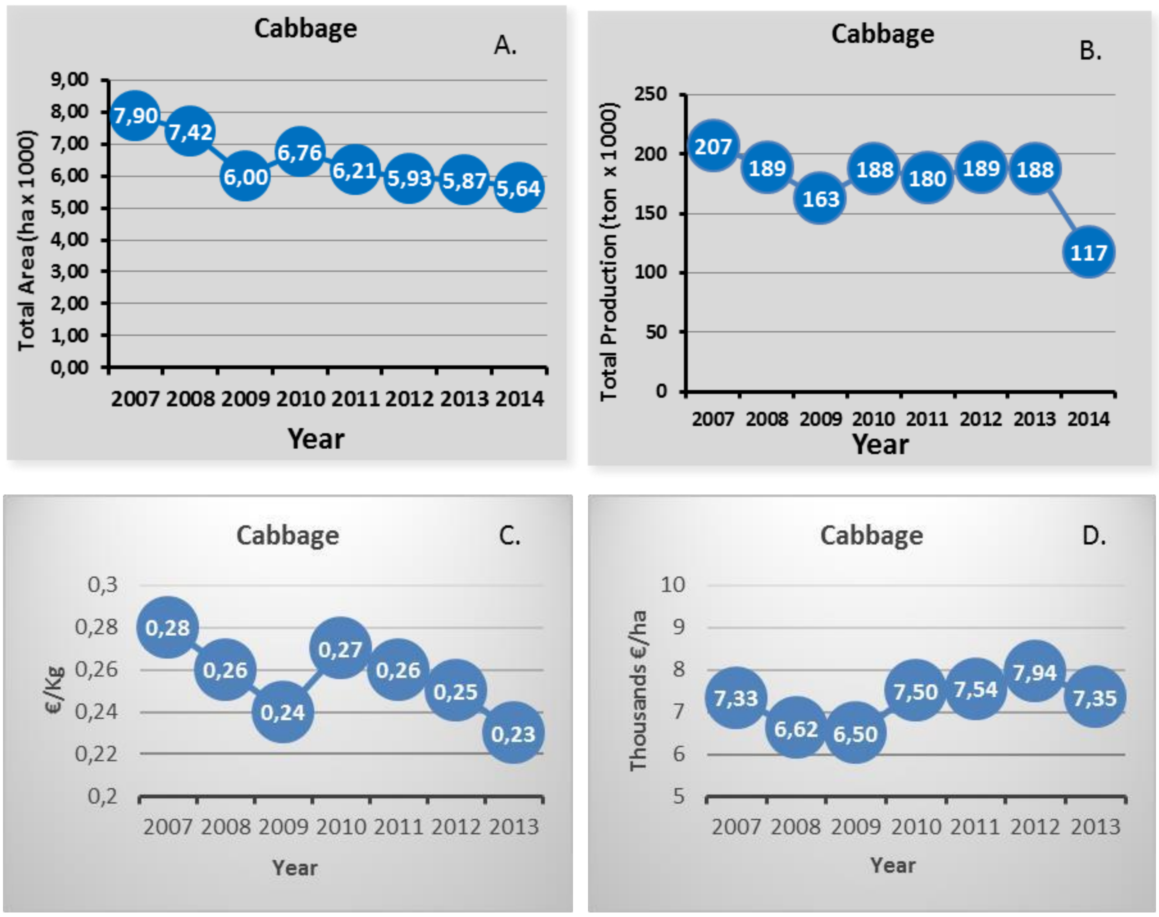


Figure 24 (A-D). Total area (A) and total production (B) of cabbage cultivated in Greece during the years 2007-2014 and yearly average of the sales price (C) for cabbage and average gross revenues (D), during the years 2007 - 2013 (data from the Greek Ministry of Rural Development and Food).

Cabbage is a cool-season crop which is producing heads from summer until spring, depending on the region, the variety and the sowing period. For example, in Central Greece seeds are sown in nurseries at early spring and cabbage heads are harvested during summer, whereas in the colder regions of Northern Greece sowing is taken place at May-June and harvesting lasts from autumn until mid-winter. In areas with mild winter (e.g. Evoia, Attica, Peloponnese) seeds are sown in August-September and production starts next spring. Retail prices (Fig. 25) are higher during late spring to early summer, due to a relative shortage of the product. It must be stressed that, contrasting to other leafy vegetables, cabbage can be stored for a long time, for up to 6 months from harvest, thus, it is available in markets throughout the year.

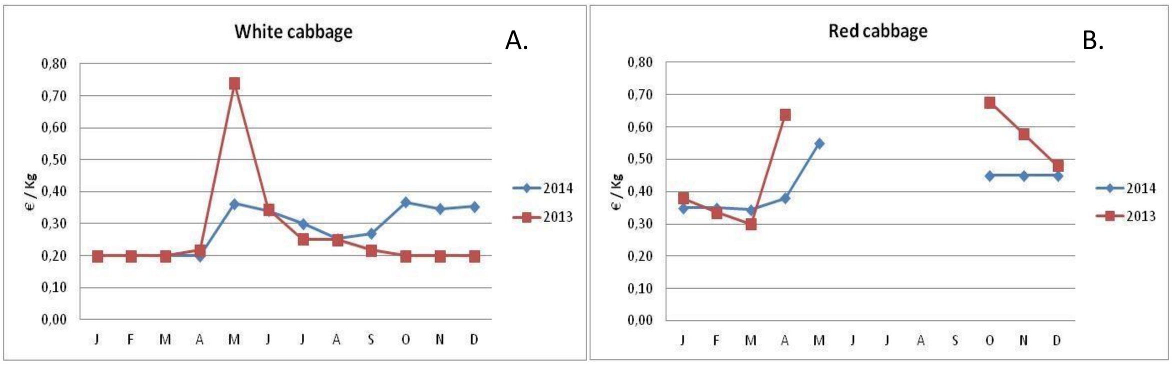


Figure 25 (A-B). Seasonal variation of white (A) and red cabbage (B) retail prices in the Central Vegetable Market of Athens, during the years 2013 and 2014.

Although a biennial crop from seed to seed, cabbage is cultivated as an annual crop for production of cabbage heads. Heads consist of leaves that overlap one with each other, which are borne on a short thick stem. Cabbage plants are cold-tolerant and can withstand temperatures as low as -10°C for short periods, although optimum mean temperatures range between 15-20°C. Plants tent to prematurely produce flower stalks (bolting) during the first year of cultivation when exposed for long at low temperatures (e.g. 5-6 weeks at <10°C), after the 4-5 true leaves stage. Contrasting to cauliflower and broccoli, this phenomenon is undesirable in cabbage, as it makes heads unmarketable. As susceptibility to bolting largely depends on the cultivar, it is necessary to select tolerant cultivars to premature flowering during winter cultivation, especially in areas of cold winter. However, mid to low temperatures close to, or during harvest, tend to improve the taste and odour of the heads. On the contrary, cabbage does not withstand heat during summer and temperatures >25°C impair the density and firmness of the heads.

Cabbage is grown satisfactorily in virtually all soil types. For early production, sandy or sandy-clay soils are preferred, and in general, deep, fertile, rich in organic matter soils which drain well provide higher yields of quality products. The optimum pH for cabbage crop is between 6.0-6.5, as moderate acidic soils (pH<5.5) tend to increase the occurrence of Mo deficiency, as well as the infection from the "clubroot" disease caused by the fungus *Plasmodiophora brassicae*.

The preparation of soil follows the general rules for cultivation of field vegetables. Crop is established by transplanting seedlings at the 4-5 true leaves stage, which are grown in nurseries for about 30-45 days. 30-50 g of seeds are adequate to produce plants for 1 str. When transplanting is done under adverse conditions (e.g. winter), seedlings must be "hardened off" by gradual exposure to low temperatures and/or limitation of irrigation. Cabbages take up large spaces in the field, so the usual planting distances in Greece are 40-60 x 30-45cm for early varieties and 60-75 x 45-60 cm for late production. In order to extend the harvesting period and to increase the availability of fresh products to markets, farmers are advised to transplant at intervals, every 2-3 weeks.

Cabbage plants are demanding in soil fertility. A cabbage crop producing 5 ton. of heads and 3 ton of leaves per 0.1 ha, removes from 0.1 ha of soil about 22 kg N, 9 kg P_2O_5, 22 kg K_2O and 5,6 kg MgO. In general, earlier varieties need less fertilization than those that produce later. Fertilization is applied as base dressing (2.5-5.0 ton per 0,1 ha of manure plus inorganic fertilizers, adding 1/3 of total applied N and the whole quantity of P and K needed for the crop; e.g. 40-50 kg per 0.1 ha of ammonium sulphate, 25-30 kg per 0.1 ha triple superphosphate and 15-20 kg per 0.1 ha potassium sulphate, or, alternatively, 30-40 kg per 0.1 ha of compound fertilizers such as 20-1020, 15-15-15 etc.). Sulfur availability favours production, head quality and dietary characteristics (i.e. increase in glucosinolates content), whereas deficiencies in B and Mo are commonly observed. The rest of N is applied as side dressing, usually in 1-3 applications with 15-25 kg/0.1 ha per application of ammonium nitrate (or calcium ammonium nitrate in acidic soils), during the period of plants and heads rapid growth. When drip-irrigation systems are employed, it is preferable to use fertigation, with 100200 ppm N, 20-60 ppm P and 100-250 ppm K, without the need for application of base dressing. Excessive N application should be avoided, since it results in rapid plant growth and the formation of less firm heads, or to splitting of heads, especially in combination with adequate irrigation during the last stages of head growth, towards harvesting.

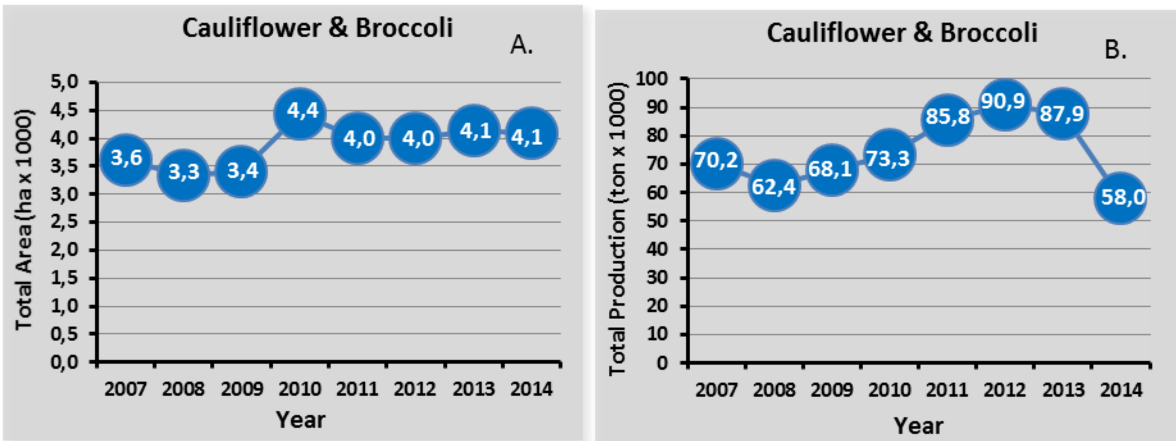
Plants should be irrigated even during winter, either by furrows, low-flow sprinklers (preferred), or even drippers in the case of water shortage. Water supply to soil should be uniform and frequent, since uneven irrigation results in head splitting. Water should be of good quality, preferably with adequate boron content. Cabbage is moderately tolerant to soil and irrigation water salinity. Irrigations should be limited towards harvesting to avoid head splitting, due to continuous production and expansion of new leaves within the heads.

Depending on the season and the variety, cabbage plants need 60-150 days from transplanting to harvest, and based on that, varieties can be classified as "early" (50-

60 days - production of small-sized heads), "mid-early" (90-95 days, heads of typical size) and "late" (up to 130 days – large-sized heads). Heads at harvest should be firm, dense and tender, as tenderness indicates freshness. "Overmatured" heads tend to split and to decay inside, whereas early harvesting results in less dense heads of inferior weight and storability. Yields are greatly influenced by the cultivation season, the type of cabbage (white/ white-green types produce more than red or savoy types), the variety used (lower in early varieties) and in Greece typically range between 3-4 tons per 0.1 ha for white/white-green types, although late varieties may yield up to 6 ton per 0.1 ha.

1.1.13 Cauliflower & broccoli

Cauliflower and broccoli are cultivated for their edible immature flower heads ("curds" in cauliflower as are mainly formed by flower primordia and "heads" in broccoli since they consist of flower buds), which are harvested together with the upper part of the fleshy flower stalk. Similarly to cabbage, they are cool season crops. Cauliflower is mainly produced and consumed in northern Europe, whereas broccoli is most preferred in the southern European countries. However, the last few years there is an increasing interest in broccoli throughout Europe, due to its exceptional nutritional characteristics. Despite of the increasing interest in broccoli, statistics for this crop are not available and are presented together with those of cauliflower (Fig. 26A-D). From 2009 onwards, the cultivated areas with cauliflower and broccoli are increased, followed by a relatively greater increase in total production, which, in combination with the higher farmers prices per kg of produce, resulted in raised farmers income per str.



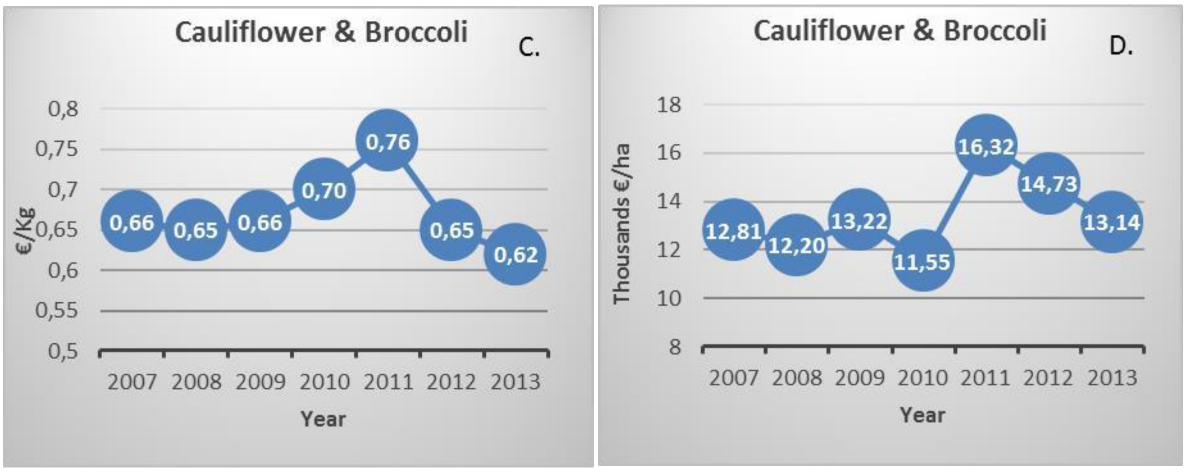


Figure 26 (A-D). Total area (A) and total production (B) of cauliflower and broccoli cultivated in Greece during the years 2007-2014 and yearly average of the sales price (C) for cauliflower & broccoli and average gross revenues (D), during the years 2007 - 2013 (data from the Greek Ministry of Rural Development and Food).

Nonetheless, imports of cauliflower to Greece used to be higher than the exports, in both quantity and value; however those differences are reduced over the last years, as exports substantially increased and so, during 2012 imports exceeded exports (Table 12). Greece could export large quantities of these species, since winter production is possible due to mild winter conditions in our country, while temperatures in northern Europe do not allow production during this season. Despite its economic importance, there are no data on broccoli imports and exports.

Table 12. Quantities and values of imported and exported cauliflower during the years 2003-2012 in million € and tons, respectively (Olympios, 2015).

Year	Imports		Exports	
	Tons	million €	Tons	million €
2003	6,416	4.65	24	0.03
2004	6,651	4.46	28	0.03
2005	3,206	3.05	218	0.08
2006	2,933	3.37	127	0.08
2007	4,976	4.33	828	0.23
2008	4,873	3.81	1,386	0.40
2009	4,744	4.54	1,113	0.34
2010	4,726	4.51	2,188	0.80
2011	4,996	4.09	3,380	1.62
2012	2,431	2.10	4,321	2.13
Mean	4,595	3.89	1,361	0.57

Similarly to cabbage, cauliflower and broccoli main areas of production are the island of Evoia, the Perfecture of Thessaloniki and the region of Marathonas, close to Athens. Traditionally, cauliflower and broccoli were cultivated in Greece during winter, as both species need exposure to low temperatures for producing flower heads (vernalization). Nowadays, the development of varieties with minimal needs of low temperatures (early varieties), allow the production of cauliflower and broccoli all-year round, even during summer. However, most of the production is concentrated on the cool period of the year, as illustrated from the prices that are higher from April until September due to a relative shortage of those products (Fig. 27).

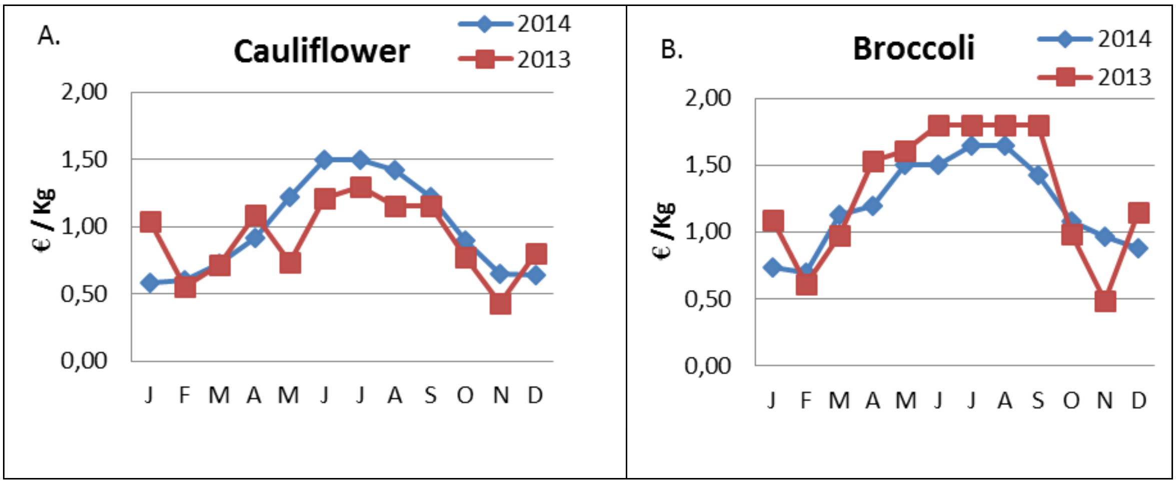


Figure 27 (A-B). Seasonal variation of cauliflower (A) and broccoli retail prices (B) in the Central Vegetable Market of Athens during the years 2013 and 2014.

In general, there are numerous of cauliflower and broccoli varieties ad hybrids, with differences in color, shape, size and period of cultivation. In Greece, white cauliflower curds are preferred and varieties and hybrids can be classified as (i) "early" or "Snowball" types, which are widely used and produce curds after about 15-20 leaves, because they do not require exposure to low temperature for flowering induction, and

(ii) "late" or "winter" varieties which produce curds after 25-30 leaves and are cultivated during winter, as they require longer cool periods to initiate flowering. In broccoli, cultivars are mainly classified to "calabrese" types which form a large head on a thick flower stalk and "sprouting" types which produce a number of small heads on a branched flower stalk. Similarly to cauliflower, there are broccoli varieties and hybrids which are planted in autumn, winter and spring, depending on their requirements for vernalization. Farmers should pay attention to select the proper variety for each cultivation period, as winter cultivars do not produce curds or heads in spring planting and spring ones produce small heads very early if they are cultivated in winter.

Cauliflower and broccoli cultivation follows the basic principles of the cabbage crop. However, cauliflower plants are more demanding in climate than cabbage, as temperatures above 25°C seriously impair the quality of curds. In general, cool temperatures favor the production and quality of cauliflower plants, although temperatures should not frequently fall below 8°C. Broccoli is not as sensitive to high or low temperatures as cauliflower. In addition, cauliflower is sensitive and broccoli moderately sensitive to soil salinity, and special care should be taken to protect curds and heads from diseases, insects and especially direct sunlight which may impair the color of the heads. In some cases producers have to cover cauliflower curds with leaves in order to protect them from sunlight, although nowadays there are varieties in which the upper leaves bend over the curds, providing shade. In addition, cauliflower and secondly broccoli, present several physiological disorders under unfavorable climate and soil conditions (e.g. blindness of the center meristematic region due to low temperatures, "buttoning" appearance of the curds when plants produce curds at a young stage of growth, "ricey" appearance of the curds as a result of high temperatures after the induction of the curd production, "whiptail" due to Mo deficiency, etc.). It is obvious that, in relation to other cruciferous vegetables, cauliflower and to a lesser extent broccoli need special attention and additional cultural techniques so as to produce high yields of good product quality. Therefore the cost of production and the risk of crop failure are increased, but on the other hand as seen from Figs 24D (cabbage) and 26D (cauliflower and broccoli) farmers income per cultivated area is nearly doubled in cauliflower and broccoli compared to cabbage.

Depending on cultivar earliness and cropping season, cauliflower curds are usually harvested between 85-125 days after transplanting, although there are late varieties which need up to 170-210 days. Broccoli heads are usually harvested between 65-105 days from transplanting. In both crops harvesting is performed two-three times, since curds and heads do not mature simultaneously and they must be at a suitable stage of growth, before the initiation of flowering which leads to curd loosening in cauliflower and flower opening in broccoli. Cauliflower yields up to 1,500-3,000 kg per 0.1 ha. For broccoli, mean yields in Greece range from 2,000-3,000 kg per 0.1 ha which are relatively high compared to other countries, such as England (200-550 kg per 0.1 ha) and U.S.A. (700-2,000 kg per 0.1 ha). Unlike cabbage, cauliflower and broccoli cannot be stored for a long time; therefore farmers should take into account the time of harvesting in relation to the adequacy of deficiency of those products in the markets, in order to achieve high prices.

1.1.15 Onion (*Allium cepa)*

Onions probably originate from Central Asia. Ancient Greeks knew it, described it and indicated its pharmaceutical properties. In Greece, according to the data on the area under vegetable cultivation in 2012, it holds the 4th position after potatoes, watermelon and tomatoes. It is cultivated throughout Greece, but Voiotia, Lakonia and plain of Thessaloniki are the main areas of cultivation.

Onion has a life cycle of between 4-9 months. 4 months is the biological cycle when small bulbs are planted (asexual or vegetative propagation), 6 months when seeds are sown in spring and 9 months when seeds are sown in autumn. It has two cropping seasons. The first one starts in spring and ends in July and the second one starts in October and ends in May.

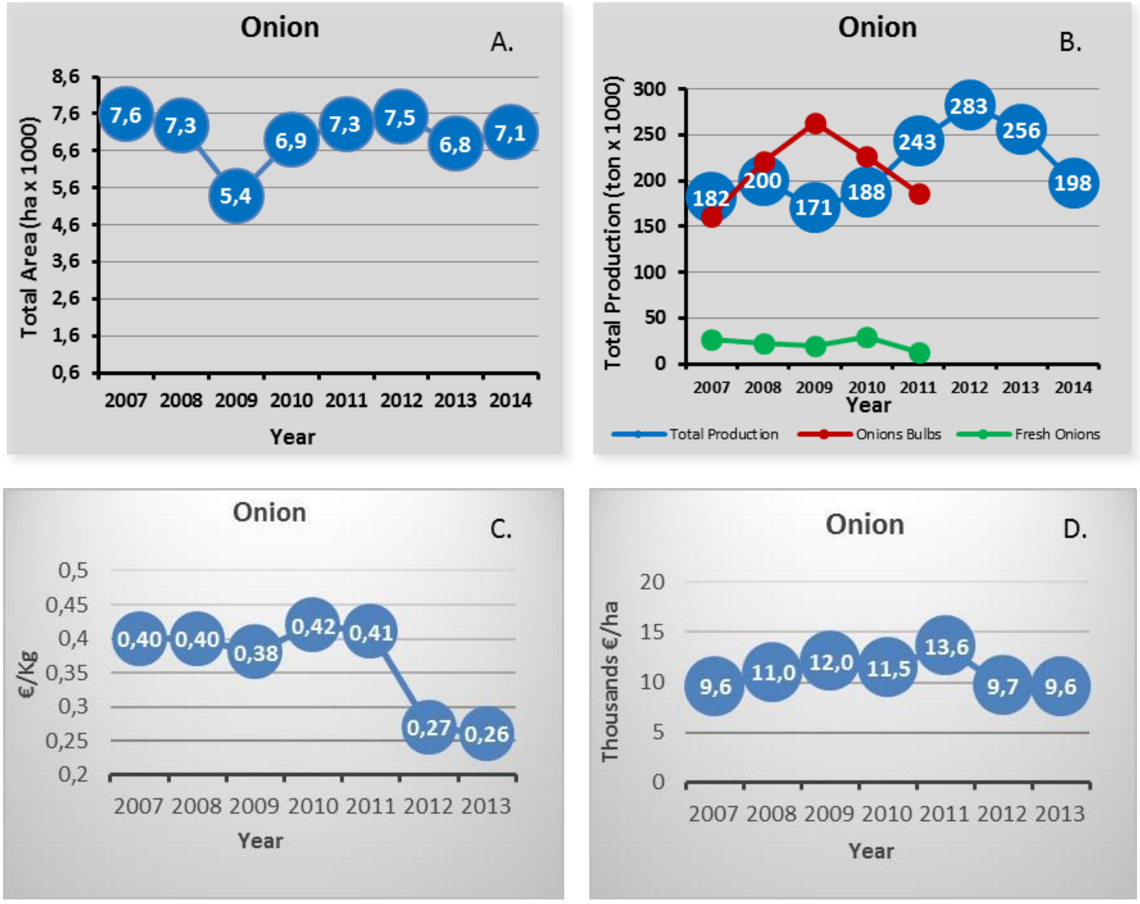


Figure 28 (A-D). Total area (A) and total production (B) of onion cultivated in Greece during the years 2007-2014 and yearly average of the sales price (C) for onion and average gross revenues (D), during the years 2007 - 2013 (data from the Greek Ministry of Rural Development and Food).

While the last two years there is a great reduction in the price per kg, the income per hectare remains at 10,000 euros since there is an increase in the average yield per hectare.

Main varieties for cultivation:

A) Long photoperiod (spring sowing)

Goldmine (IDEAL 11): Yellow bark onion, white flesh, spherical shape, early and productive.

Dorata di Parma: Elongated cylindrical onion with a golden yellow color. Resistant to fusarium.

Morada de Amposta: Large onion, spherical shape, reddish color, white flesh with good retention in the warehouse.

Ideal 15: reddish-brown color, spherical shape

Dorada di Polonia: Large onion with yellow bark color.

Yellow Sweet Spanish (Peckaman Strain): Oversized spherical onion with yellowbrown bark color.

B) Short photoperiod (autumn sowing)

Red cross F1: Middle late hybrid, oblate ellipsoid shape, deep red color, very productive (80-100 tons / ha)

Red Star (common variety): Conical shape with dark red color crimson and yields 90100 tons / ha.

Top Keeper F1: Spherical shape, brown-yellow color

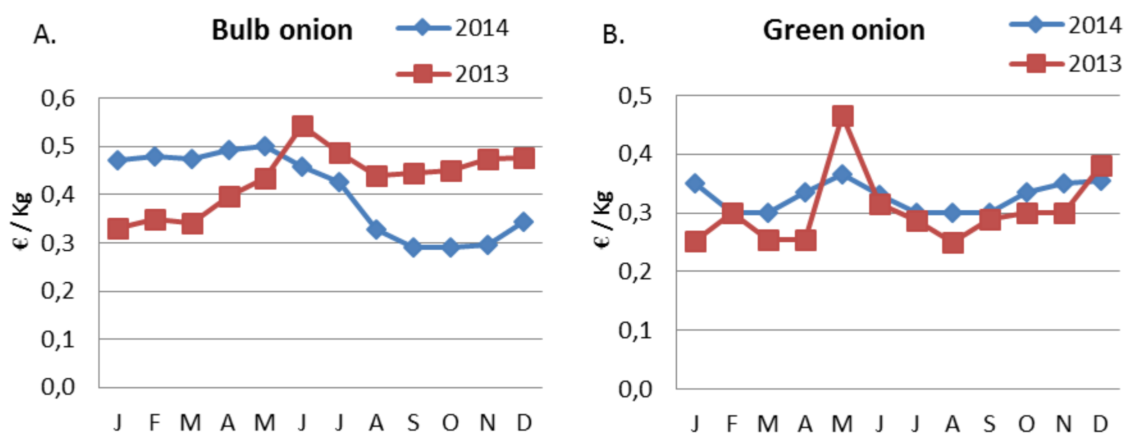


Figure 29 (A-B). Seasonal variation of bulb (A) and green onion (B) retail prices in the Central Vegetable Market of Athens during the years 2013 and 2014.

Onion grows well in neutral or slightly acid soil (pH = 6.0-7.8). It is not a very demanding plant but gives greater returns in light-textured loamy soils with good organic matter content. Heavy clay, gravel and salt soils with electric conductivity over 4 dS /m, should be avoided. Onion is considered as a cold season plant in early stages and as a hot season plant during bulb growth. The temperature significantly affects bulb formation and growth, which is favored at temperatures from 16 to 26°C. The photoperiod is the second most important climatic factor and this is why onions are divided into short-day and long-day onions. High air humidity influences the incidence of fungal infections, particularly of downy mildew.

In the field, 1-2 months before showing, a ploughing in 20-30cm deep is required. A few days before sowing milling and base dressing (recommended 500 kg/ha. 11-15-15 and 20 to 40 tons/ha. digested manure) are necessary. If a seed sowing machine is available, seeds are sown on level ground or in lines (20-40cm x 8-10cm). Alternatively, seeds are sown across the surface of the soil by hand. Required quantity of seeds: 10kg/ha. If small bulbs are used, then 750-1000 kg/ha. are required at the same spacing.

Sprinkler irrigation is applied with a "cannon" that is used with large injectors. Irrigation is applied in 15 doses from March to June and the total quantity of water required in a spring crop is approximately 3600 m^3 /ha. Apply one or more doses of side dressing: ammonium nitrate at an amount of about 500 kg/ha. Weeds are a major problem because onion has a low growth rate. Pre-emergence and post-emergence herbicides (in the 3-leaf stage) are used. Pre-emergence herbicides can be used: 2 parts of Dachtal and 1 part of Paraquat. Post-emergence herbicides can be used: Propaquizafop, Cycloxydim, Oxyfluorfen, Bentazone. Weeding and shallow hoeing complement the weeds extinction.

Harvesting begins when the top of the 50% of the plants bend to the ground. A few days before harvesting irrigation is stopped. The plants are pulled by hand and placed into shallow heaps in the field for curing for 3-10 days. Then the aboveground dry part of the plant is clipped off and the bulbs are transported to the warehouse where they are sorted and packaged in netting bags of 25-50 kg. Long term storage conditions for onion are 0° C with 60-70% humidity. Average yield of onion is 30-40 tons/ha for spring crops and 50-80 tons/ha for autumn crops.

1.1.16 Garlic (*Allium sativum)*

Garlic originates from Central Asia and the Mediterranean. It has been mentioned in texts of ancient Chinese, Egyptian and Greek writers. It is mainly grown in Orestiada, Rodopi, Evoia, Aitoloakarnania, Corfu Island and Drama. The cultivation period of garlic lasts about 6-8 months, 6 months in cold areas of North Greece (spring crop) and 8 months in warmer regions (autumn crop). Spring crop starts in spring and ends in July-August, and autumn crop starts in October-January and ends in April-May.

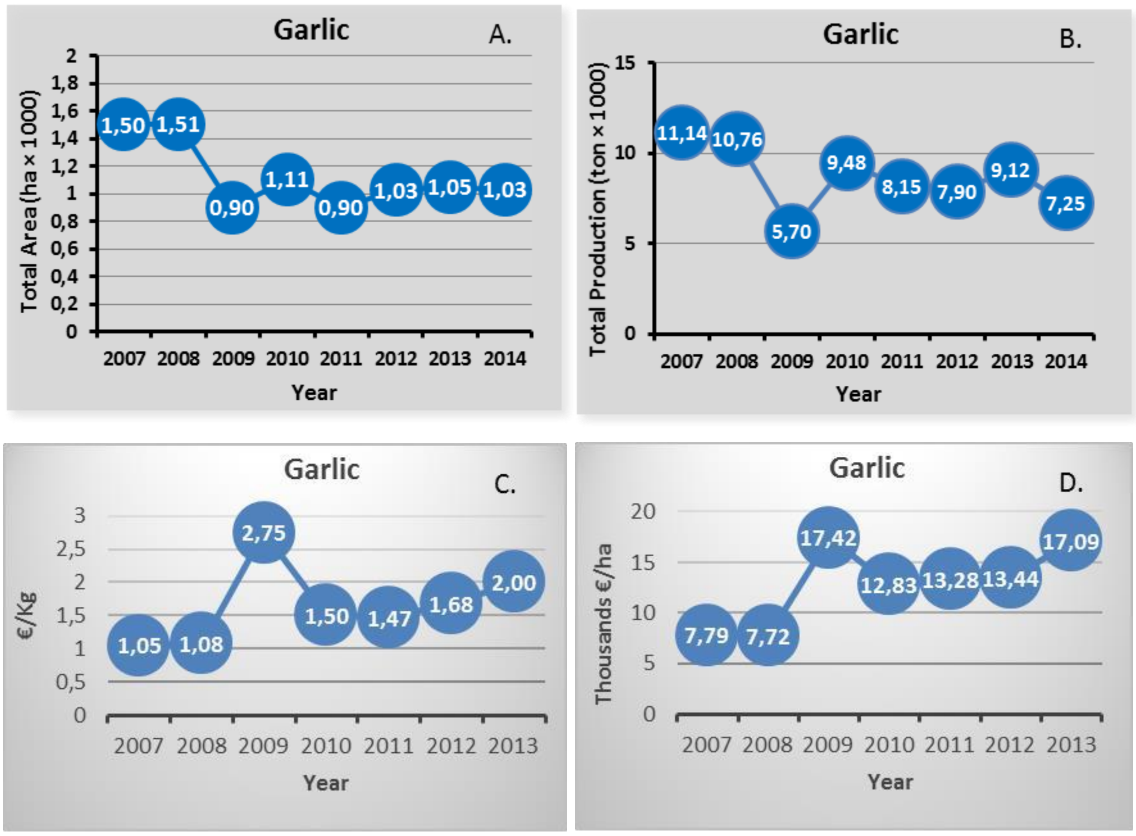


Figure 30 (A-D). Total area (A) and total production (B) of garlic cultivated in Greece during the years 2007-2014 and yearly average of the sales price (C) for garlic and

average gross revenues (D), during the years 2007 - 2013 (data from the Greek Ministry of Rural Development and Food).

There is a stability in the cultivated area (about 1100 ha) between 2007 and 2014 with an average income of 15,000 euros per ha in the last 6 years. Basically there is one variety which is cultivated in Tripoli. It has a white oversized bulb with 6-8 cloves.

Garlic usually grows well in a fertile (45-60cm depth) well-drained soil, rich in organic matter. Also it grows well in neutral or slightly acid soils (pH 6.0-7.0). Garlic has almost the same requirements as the onion. It is also considered as a cool season plant in the early stages of vegetative growth and as a hot season plant during bulb formation and growth. High air humidity influences the incidence of fungal infections and it is not desirable during bulb maturation, e.g. before harvesting.

Procedures before planting: 1-2 months before planting, a thorough plowing of 20-30cm depth is required. A few days before planting, milling is required. At the same time, mounds should be made and base dressing fertilizers (recommended: 200 kg/ha. 26-0-0 + 150-200 kg/ha 0-48-0 + 200-400 kg/ha 0-0-48) and digested manure (if available 20-40 tons/ha.), are incorporated into the soil. Separate cloves from the bulb before planting. Select the larger cloves from the periphery of the bulb. The percentage of good cloves obtained from one kilogram of the bulbs is 75-80%. Procedures after planting: Planting is performed in mounds of 15-20cm height and at a spacing of 3035cm x 8-10cm. Required quantity of cloves is about 500-1500kg/ha. Surface irrigation is applied, once a week in the winter and every two days in the spring and the summer. Irrigation water requirements: 3000-3500 m^3/ha. Apply at least 2 doses of surface fertilization with ammonium nitrate at about 250 kg/ha. Pre-emergence and postemergence herbicides (when plants have 3-5 leaves) can be used. Pre-emergence: Butralin, Chlorthal-dimethyl, Pendimenthalin. Postemergence: Cycloxydim, Oxyfluorfen, Linuron, Menthabentthiazouron etc. Weeding and shallow hoeing complement the weeds extinction.

Harvesting begins 5-8 months after planting, when the top of the 80% of the plants bend to the ground. The plants are pulled by hand and placed into shallow heaps in the field for 7-10 days. Then, the aboveground dry part of the plant and the roots are clipped off and the bulbs are transported to the warehouse where they are sorted and packaged in small netting bags of three bulbs each. Alternatively, the top of the plants not cut and the plants are entangled forming pigtails. Long term storage conditions for thoroughly cured garlic bulbs are -2°C and 60% humidity, where they can be stored for 8 months. Average yield of garlic is 5-10 tons/ha, or 200-300 thousands of bulbs/ha.

1.1.17 Leek (*Allium ampeloprasum var. porrum*)

Leek basically originates from the Mediterranean. It is mainly grown in geographic regions of Central, Eastern and Western Macedonia, Thessaly, Thrace and Athens. The biological cycle of leek is about 7-9 months. Sowing escalates from February to May.

All data presented in graphs show a stability in the cultivated area and total production with an average income of 12,000 euros per hectare.

The main varieties of leek that can be used are "Macedonia" also known as "reed", "Argos", "Artakis", Swiss Giant. Leek grows well in light- textured loamy soils with optimum pH 6.5-7.5. Leek is quite resistant to low temperatures down to -17°C, but the optimum growth temperature is 15-20°C.

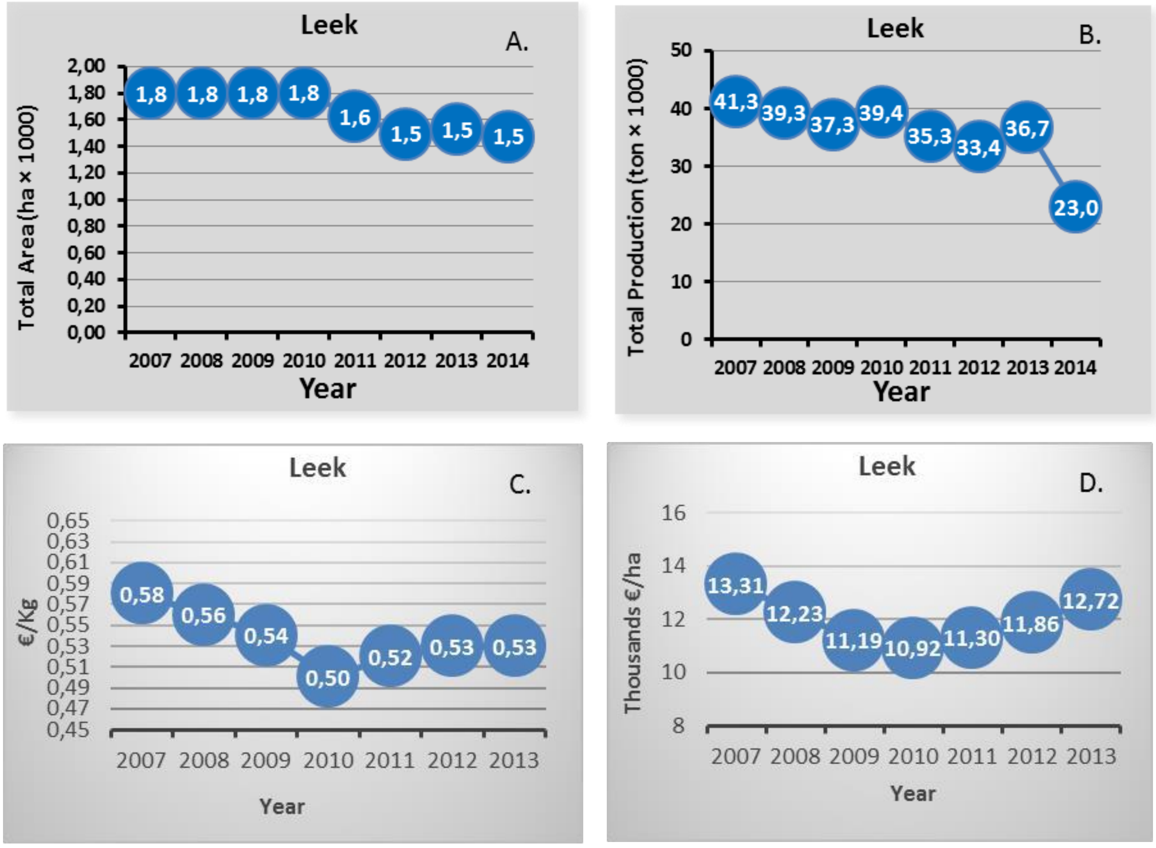


Figure 31 (A-D). Total area (A) and total production (B) of leek cultivated in Greece during the years 2007-2014 and yearly average of the sales price (C) for leek and average gross revenues (D), during the years 2007 - 2013 (data from the Greek Ministry of Rural Development and Food).

Procedures before planting: In the mid-summer season a plowing to a depth of 30-40 cm is required. Seeds are sown in seedbeds from February to May. Seedlings remain in the seedbed until the diameter of the stem is 0.9-1.2cm. and the height of the plant is 25 - 30cm (2.5-3.5 months after sowing). Also, few days before transplanting milling is required and base dressing (recommended 1000 kg/ha 11-15-15) and digested manure (3 tons/ha). are necessary. Transplanting is made on level ground and formed into abnormalities at a spacing of 20-25cm x10-15cm.

Procedures after transplanting: Surface irrigation is applied and the amount of water required is approximately 3750-4000 m^3/ha. Apply 3 doses of side dressing: ammonium nitrate at 400-450 kg/ha. Pre-emergence and post-emergence herbicides can be used. Pre-emergence: Butralin, Pendimenthalin pesticide and Postemergence::

Cycloxydim, Oxyfluorfen, Linuron, Menthabentthiazouron Loxynil. Weeding and shallow hoeing complement the weeds extinction.

Harvesting begins when the stem has a diameter > 2.5cm. The plants are pulled by hand and the roots are cut off immediately. Subsequently strain of the aged sheets is purified and a part of the leaf blade is clipped off. Then they are sorted and baled in bales weighing 3-10 kg. Storage conditions for leek: 0^{o} C with 90-95% humidity. Average yield of leek is 30-50 tons/ha.

1.1.18 Green Bean (*Phaseolus vulgaris* L.)

Common bean, grown for production of either fresh immature pods consumed as vegetables (green bean), or dry seeds, is a warm-season crop that does not tolerate frost or long periods of exposure to near-freezing temperatures at any stage of growth. Therefore, the open-field cultivation of common bean (*Phaseolus vulgaris* L.) for fresh pod production is more frequent in southern European countries. Spain is the leading producer of green bean in Europe with 99,000 ha and an average yield of 60 ton ha^{-1}, followed by Serbia, with 20,000 ha and an average yield of 50 ton ha^{-1} according to FAO statistics (FAOSTAT, 2012). Greece ranks in the 6^{th} position in terms of cultivated area with a total area of 5,650 ha but a low yield performance that averaged only 10.4 ton ha^{-1} in 2012 according to data of the Greek Ministry of Rural Development and Food. As shown in Figure 32A, the area cultivated with green bean in open field was relatively stable in the last years ranging from 5,650 to 6,500 ha, while the total production in the same years ranged from 46,260 to 66,100 tons, which corresponds to a yield performance fluctuating from 8.20 to 10.17 ton ha^{-1}. This score in yield, when compared to those recorded in Spain or Serbia, stresses the need to drastically increase the average yield performance in Greece by improving cultural techniques and selecting more productive cultivars. Extending the growing period by using indeterminate climbing cultivars that are appropriately supported, so as to optimize land use, is the most efficient strategy to increase yield performance of field-grown green bean in Greece.

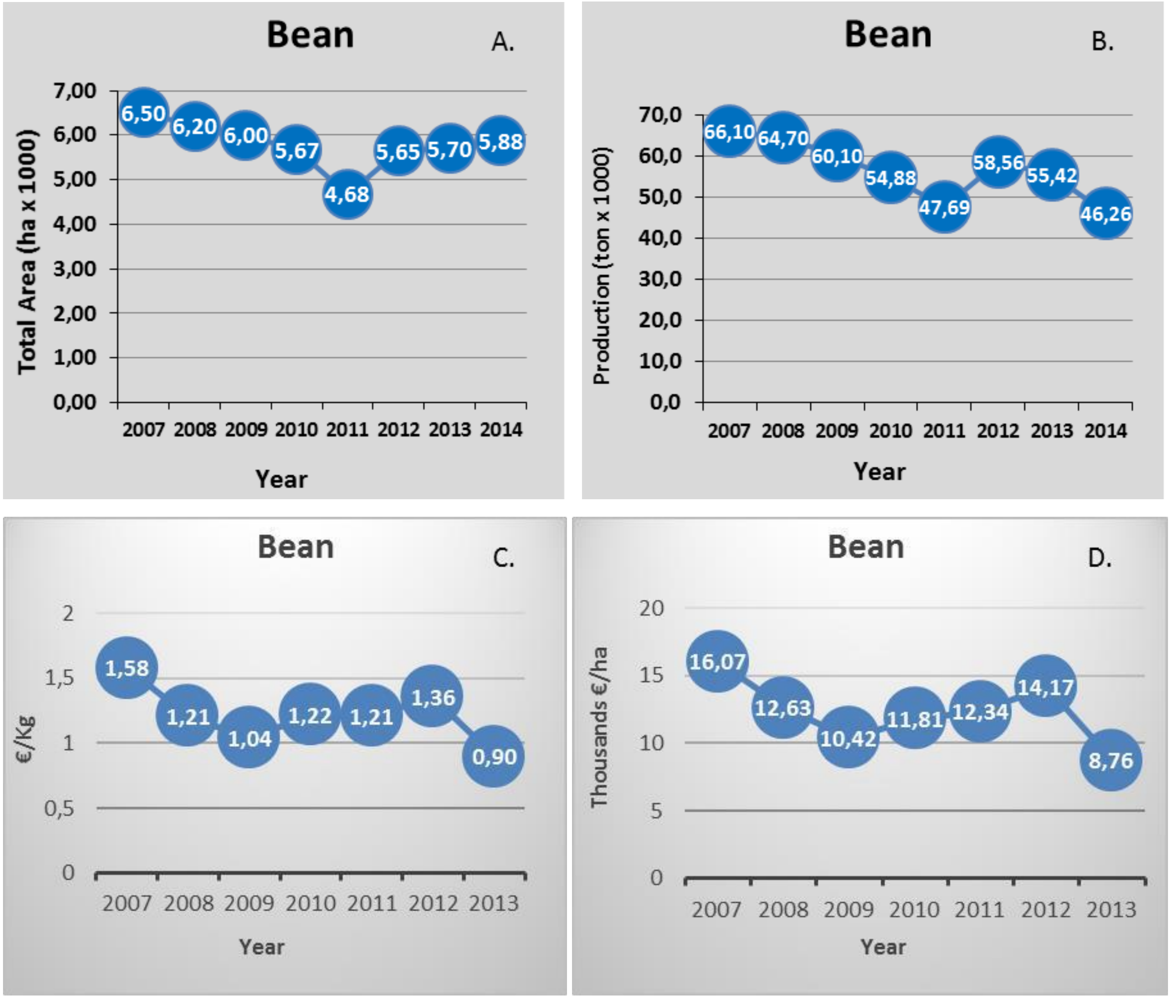


Figure 32 (A-D). Total area and total production of green bean cultivated in open fields in Greece during the years 2007-2014 and yearly average of the sales price for green beans and average gross revenues, during the years 2007 - 2013 (data from the Greek Ministry of Rural Development and Food).

As shown in Table 13, the leading region in domestic production of green bean in open fields is Central Macedonia with nearly one third of the total production, followed by Western Greece and Central Greece. These data show that green bean production in open fields takes place mainly in regions with lowlands that are not most suitable for early production, and is mainly intended for summer production or for freezing.

Table 13. Cultivated area and production of green bean pods in open fields allocated into the 13 regions of Greece in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area	Total production	Mean production

	(ha)		(ton)	(ton/ha)
Eastern Macedonia & Thrace	650	11,1	4.140	6.36
Central Macedonia	1,815	30,8	15,968	8.80
Western Macedonia	200	3,4	850	4.25
Epirus	300	5,1	2,329	7.75
Thessaly	313	5,3	2,907	9.28
Ionian Islands	105	1,8	53	0.50
Western Greece	658	11,2	5,520	8.39
Central Greece	901	15,3	8,088	8.98
Attica	63	1,1	100	1.58
Peloponnese	516	8,8	2,918	5.65
		(%)		
North Aegean Islands	25	0,4	173	7.06
South Aegean Islands	52	0,9	190	3.66
Crete	286	4,9	3,030	10.58
Total	5,885	100	46,264	7.86

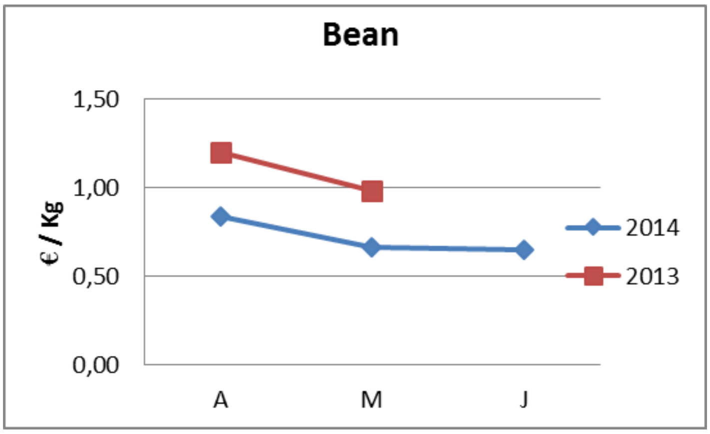


Figure 33. Mean monthly prices for green beans during the years 2013 and 2014 at the Thessaloniki Central Fresh Fruit and Vegetable Wholesale Market.

In Greece, the harvesting season of green bean in open field crops starts in June and ceases in September. During the rest of the year, green bean consumption is supplied mainly from greenhouses. The monthly evolution of the average sales price for green bean during the years 2013 and 2014 are shown in Figure 33. The obtained data indicate that the prices during the effective period of green bean production in the field are higher at the beginning of the harvesting season (i.e. June) and decrease gradually to about 0.7 € kg^{-1}. Given the strong competition in the international market, a substantial increase in prices is not anticipated in the next years. Thus, any increases in the profitability of bean crops in open fields are depending on yield increases to much higher levels than the currently reported average yield per ha in Greece. Nevertheless, green bean might be included in crop rotations, especially by farmers producing organic vegetables.

Table 14. Imports and exports of green beans in year 2003-2012 in million € and tons, respectively (Greek Ministry of Agriculture).

Year	Imports		Exports	
	Tons	million €	Tons	million €

2003	2,211	2.34	94	0.15
2004	2,676	2.13	96	0.24
2005	2,439	1.75	100	0.18
2006	2,547	2.35	25	0.01
2007	2,179	2.24	237	0.12
2008	2,172	2.56	299	0.13
2009	1,616	2.24	183	0.13
2010	889	1.41	693	0.56
2011	979	1.16	146	0.15
2012	723	0.62	321	0.43
Mean	1,843	1.88	219	0.21

1.1.19 Green peas

Pea is one of the most popular pulse crops and has various uses for human consumption. Immature pea seeds (green peas or 'vining' peas) are usually canned or frozen and used as the familiar vegetable. 'Green pea' is the term used by the FAO for peas harvested when the seed is still green and succulent to be eaten as a vegetable either fresh or processed.

The world production of green peas in 2011 was more than 27 million tons. Between 2005 and 2011, an increase in cultivated area, total production, and yield of green peas has been recorded in Europe, including most southern European countries and Greece (Table 15). These data indicate that the cultivation of green peas for human consumption attract an increasing interest among growers in the last years.

Table 15. Comparison of cultivated area, total production, and yield of green peas in Europe between the years 2005 and 2011 (FAOSTAT 2014)

Cultivated area, production, and average yield of green peas in different parts of Europe						
	2005			2011		
European region	Area	Production	Yield	Area	Production	Yield
	(ha)	(ton)	(ton ha^{-1})	(ha)	(ton)	(ton ha^{-1})
Eastern Europe	239,890			295,949		
Northern Europe	381,168			497,297		
Western Europe	488,845			759,284		
Southern Europe	182,732			265,374		
Southern Europe	149,554			264,178		
Europe total	1,292,635			1,817,904		
Cultivated area, production, and average yield of green peas in different southern European countries						
Country	2005			2011		
	Area (ha)	Production (ton)	Yield (ton ha^{-1})	Area (ha)	Production (ton)	Yield (ton ha^{-1})
Albania	-			3000		
Bosnia & Herzegovina	-			-		

Croatia	4,011			6,060		
Greece	9,212			20,100		
Italy	71,103			99,039		
Malta	179			197		
Montenegro	-			310		
Portugal	7,965			7,490		
Serbia	-			41,204		
Slovenia	225			174		
Spain	54,759			84,104		
FYROM	2,100			2,500		

Pea is well adapted to different cropping conditions ranging between semiarid to temperate. The peas grown in Central and North Europe are sown in spring whereas in southern Europe they are mostly sown in mid-November. The optimum and base germination temperatures are around 20°C and -1.1°C, respectively. Central Macedonia and Eastern Macedonia & Thrace produce the vast majority of green peas in Greece, followed by Peloponnese (Table 16). However, while the pea production in Macedonia and Thrace is intended mainly for freezing by the food industry, the production in Peloponnese and other more southern regions (Central Greece and Attica) is mainly sold for fresh consumption. This is because the production in southern Greece is harvested earlier and achieves high prices in the fresh vegetable market (see below).

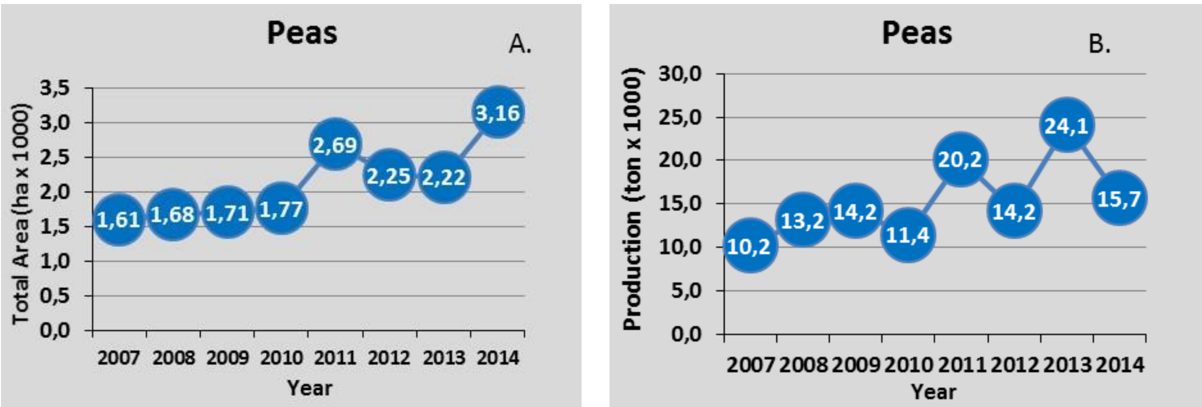


Figure 34 (A-B). Total area (A) and total production (B) of green peas cultivated in open fields in Greece during the years 2007-2014.

Table 16. Cultivated area and production of green peas in the 13 regions of Greece in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area (ha)	(%)	Total production (ton)	Mean production (ton ha^{-1})
Eastern Macedonia & Thrace	670	21.2	4,487	6.70
Central Macedonia	1,698	53.8	6,465	3.81
Western Macedonia	12	0.4	67	5.50
Epirus	19	0.6	210	11.07
Thessaly	29	0.9	63	2.20
Ionian Islands	45	1.4	0	0.00

Western Greece	305	9.7	3,150	10.33
Central Greece	185	5.9	1,124	6.08
Attica	89	2.8	45	0.50
Peloponnese	92	2.9	30	0.33
North Aegean Islands	4	0.1	29	7.25
South Aegean Islands	8	0.3	0	0.00
Crete	2	0.1	12	6.00
Total	3,158	100	15,681	4.97

The inclusion of peas in cropping systems increases the yield of the following crop. Due to the ability of pea to biologically fix N_2, this crop has reduced input requirements. Therefore, inclusion of peas in rotation schemes is an effective means to increase sustainability of crops. Yields are reduced if grown often in the same field due to root diseases and autotoxicity effects. Thus, crop rotation is also an effective cultural practice for controlling pea diseases. Ascochyta blight (*Mycosphaerella pinodes*) is a serious disease for pea. An interval of at least 6 years between two pea crops is required to reduce the amount of ascochyta blight propagules by 90%.

Green peas for fresh consumption may be harvested by hand in more batches than one. Vining peas intended for canning or freezing are harvested with specialized pea vining machines when the pods are well filled but the seeds are still tender. Yield loss at harvest can be high and these are minimized by careful machine operation. Harvesting is frequently organized or scheduled by the processors to optimize yield and tenderness of the peas.

Pea is characterized by yield instability, which is affected by many biotic and abiotic factors. Cereal crops, such as wheat, produce twice as high yield as pea in northern European countries. Consequently, pea grain must have a substantially higher price than cereal grains, considering even the longer-term rotational benefits of the inclusion of pea. However, under Mediterranean pedo-climatic conditions, the yield obtained in pea crops is more than half of that of wheat (Stoddard 2014). The seed yield of vining peas in Greece ranges between 6 to10 t ha^{-1}, although even higher yields were recorded in some Greek regions in 2014 (Table 16). Under favorable conditions, yields of up to 15 t ha^{-1} are possible in southern European countries. The better yield performance of pea in southern Europe is attributable to the possibility to sow peas in autumn in these countries, thereby closing the yield gap arising from sowing cereals in the autumn but pea in spring in northern Europe.

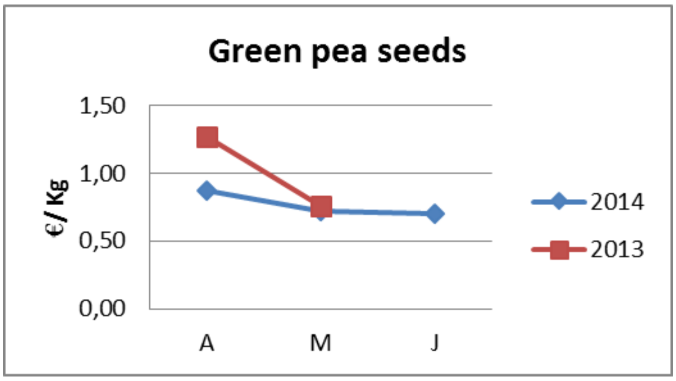


Figure 35. Mean monthly prices for green pea seeds during the years 2013 and 2014 at the Thessaloniki Central Fresh Fruit and Vegetable Wholesale Market.

The green seed yield of pea in tons per ha is about 10% to 30% of that obtained from other fruit and leafy vegetable crops grown in open fields. However, the total production cost of green peas is low because the crop is sown and not transplanted, while cultural treatments and harvesting are mechanized, although exact data is not available. The harvesting season of fresh green peas in Greece starts in April and ceases in June, depending on the longitude and altitude (i.e. the climatic conditions) in each cultivation site. The monthly evolution of the average sales price for green pea during the years 2013 and 2014 are shown in Figure 35. The obtained data indicate that the prices are much higher at the beginning of the harvesting season (i.e April) and decrease gradually to about 0.7 € kg^{-1}. Thus, for a green seed yield of 8 ton ha^{-1} and a selling price of 0.8 € kg^{-1}, a gross revenue of 6,400 € ha^{-1} can be achieved. Even higher gross revenues can be achieved in April, especially if the yield can be further increased. Given the low production cost of pea, these data indicate that early production of green peas in areas with mild winder climate in southern Greece provide good prospects to growers for a satisfactory net income, provided that a sufficient cultivation area (>5 ha) is available. On the other hand, the prices for green pea seeds intended for freezing may be lower than 0.8 € kg^{-1} and thus, larger cultivation areas may be needed to provide a satisfactory income to growers cultivating pea in Macedonia.

Taking together the above-referenced information, it can be concluded that green peas is a crop with good prospects when adapted into rotation schedules. Further improvement in yield and economic returns can be achieved by selecting cultivars with improved resistance to ascochyta blight, greater winter hardiness, and better standing ability.

1.1.20 Celery -celeriac

The cultivated plants of the *Apium graveolens* species are grouped in three botanical varieties (subspecies):

1. Celery (*A. graveolens* var. *dulce*) is cultivated for the succulent and tender petioles and leaves. It is the most important celery type in Northern Europe and America, as in Greece.

2. **Celeriac** (*A. graveolens* var. *rapaceum*) is grown for the thick, succulent root and the tender leaves, mainly in Northern and Eastern Europe
3. **Leaf celery** (*A. graveolens* var. *secalinum*) which is popular in Asia and Mediterranean countries. It is cultivated for its leaves which are harvested at a young stage and sold in bundles.

Celery is further classified as "green", in which both petioles and leaves are green in color and is mainly consumed in Northern America and Southern Europe and "white-green", which is popular in Central and Northern Europe, has white petioles and green-yellow leaves. "Blanching" in white-green celery is attained either by the use of

"self-blanching" varieties, or the employment of several cultural techniques which restrict light to plants, such as dense planting, planting in shallow furrows and ridging (earthing up), or post-harvest ethylene application.

From the botanical varieties of *A. graveolens*, celery is mainly cultivated in Greece, whereas celeriac has a minor economic importance, as only 37.3 ha of celeriac were cultivated in Greece during 2014, producing 438 tons. The cultivation area and production of celery was continuously reducing over the last 7 years, reaching at lowest levels in 2012 (Fig. 36 A-B). The main cultivation regions are Attica (accounts for 40% of the total area in Greece) and Central Macedonia (more than 10% of total area). In general, celery is cultivated close to large cities, despite the fact that it can be stored successfully under low temperatures for longer periods than other leafy vegetables. Farmer prices per kilo of produce and per ha are more or less stable over the last 7 years, providing a fair income to growers (Fig. 36 C-D). However, it should be noted that celery is demanding in climate and soil conditions as well as in cultural practices and, compared to other leafy vegetables, its cultivation lasts longer, as harvesting is usually done after 150-200 days from sowing, or 90-130 days from transplanting, depending on the cultivation season, the climate and the variety.

Celery is a cool-season crop, tolerant to even freezing temperatures (up to -3^{o}C). It is cultivated in the field for production from August until next May. Therefore, a relative shortage may be observed during summer or autumn in the markets, thereby increasing prices (Fig. 37).

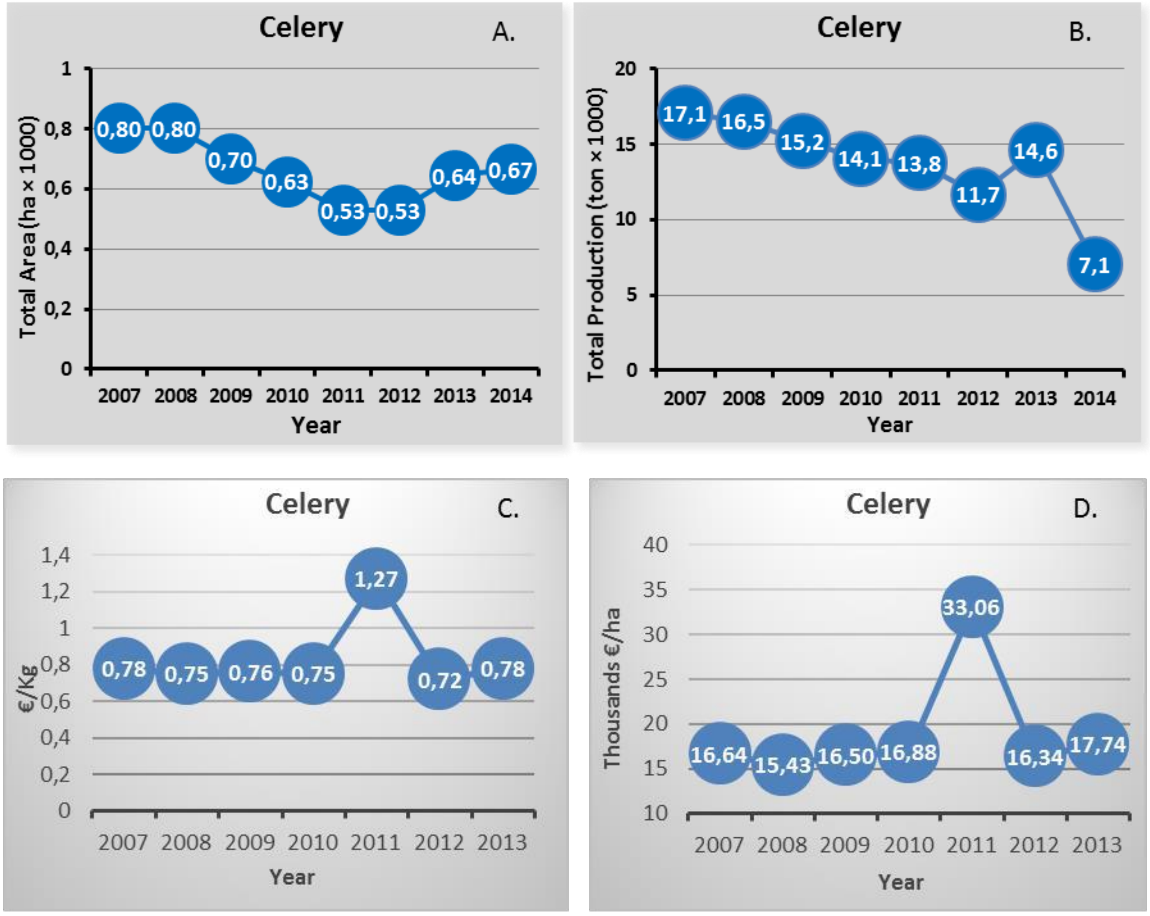


Figure 36 (A-D). Total area and total production of celery cultivated in open fields in Greece during the years 2007-2014 and yearly average of the sales price for celery and average gross revenues, during the years 2007 - 2013 (data from the Greek Ministry of Rural Development and Food).

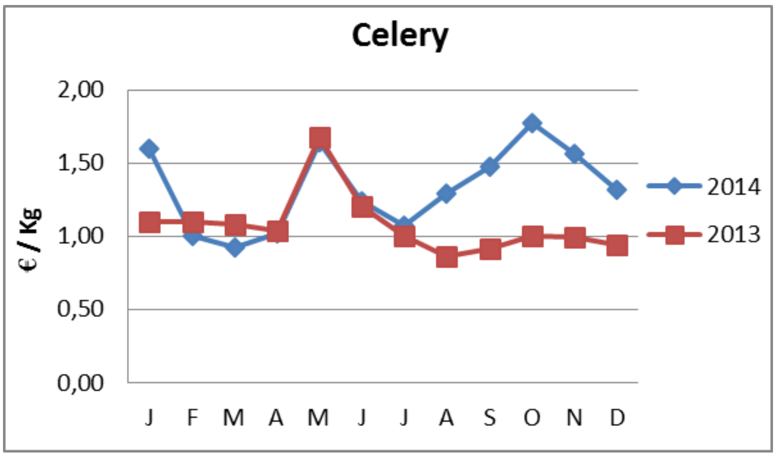


Figure 37. Seasonal variation of celery retail prices in the Central Vegetable Market of Athens, during the years 2013 and 2014.

Production in Greece does not cover the demand of domestic market. Therefore, imports are substantially higher than exports, even though the last years imports are reduced from 600-800 tons to 200-400 tons per year; however 200-400 tons of celeriac should also be added to imports. Greece imports celery from Holland, Germany and Israel. As in the case of other cool-season vegetables, growers could exploit the mild climate in several regions of Greece during winter, to produce and export those vegetables, in a period when Central and Northern European countries are unable to cultivate those crops.

Table 17. Imports and exports, in quantity (tons) and value (€) of celery and celeriac in Greece, over the years 2003-2012.

Year	Celery Imports		Exports		Celeriac Imports		Exports	
	Tons	€	Tons	€	Tons	€	Tons	€
2003	809	589,708	1.5	1,080	114	56,501	30	58,576
2004	721	507,255	2	1,287	121	97,200		
2005	592	397,301	3	1,038	280	145,925	1	705
2006	710	469,122	1.6	439	159	213,692		
2007	794	315,141	7.5	3,352	223	137,829	1,5	874
2008	608	332,348	12	4,865	383	269,035	0,5	457
2009	519	320,458	13	8,730	198	147,973	1,5	1,876
2010	420	306,615	3	13,768	385	386,913	4	938
2011	354	219,670	33	17,658	266	255,442	5	1,590
2012	178	154,502	73	21,265	106	80,789	5	5,932

Although a cool-season crop, celery grows slowly at the initial growth stages, especially under low temperatures, whereas, long periods of low temperatures cause vernalization, which leads to bolting and loss of quality and production in general. On the other hand, high temperatures during the last stages of growth seriously impair quality and plant growth. Additionally, celery produces a shallow root system and is therefore highly demanding in water, producing better when adequately irrigated, in soils of high water capacity and proper drainage. Under water scarcity yield is seriously reduced and perioles of leaves tend to get fibrous and hard. Celery plants are sensitive to soil and water salinity, so irrigation water should not have an EC of more than 1.2 dS m^{1}. Irrigation is recommended to be applied by drip irrigation, since sprinkler irrigation lead to spreading of diseases and the development of salt stains on petioles and leaves due to water evaporation. Celery plants are heavy feeders, especially during the last 4-6 weeks before harvest, when they gain most of their weight. They are particularly demanding in K, Ca, Mg and B and in general it is recommended to add 250 kg/ha 210-0, 300 kg/ha 0-48-0 and 300 kg/ha 0-0-48/52 as base dressing and 200-300 kg/ha 340-0 as side dressing in 2 or more applications during plant growth.

Plants are sown in nurseries, commonly from February until summer and are transplanted to the field, 2-2.5 months later. Celery seeds are hard to germinate, they present low germinability and they need special treatment during germination. Therefore, direct seeding is not recommended and it is better for the grower to obtain plants from commercial nurseries.

Harvest starts when plants are grown enough and petioles and leaves are still tender, as delayed harvesting results in pithy, hard and fibrous petioles and leaves. Harvesting accounts for more than the half of the total man-hours needed for the whole crop (as an estimate, 500 hours per ha are needed for harvesting, 340 hours for transplanting and 120 hours for hoeing and mechanical weed control). In domestic markets celery is sold together with the leaves; however in other countries leaves are cut and the petioles at a length of 35-40 cm are packaged in plastic bags and sent to the markets. In order to preserve the quality and to extend the postharvest life of celery, precooling should be employed soon after harvest either by hydrocooling or by vacuum cooling and plants should be kept near to 0ºC under high relative humidity (98-100%). Under these conditions, celery could be stored for more than 8 weeks, without serious loss of quality.

Typical yields in Greece range between 40-60 tons/ha, although higher yields up to 80 tons/ha can be readily achieved. In general, about 50,000-100,000 plants of 0.5 - 1.5 kg per plant are usually produced per ha, depending on season, cultivar, planting distances, climate and soil conditions. It should be noted though, that yields are lower when the produce is exported, since only a part of the plants (specifically the petioles and only a few leaves) is sold in this case.

Celeriac was not traditionally consumed in Greece, even though the last few years there is an increasing interest, as its root (in reality a swollen hypocotyl) is used in cooking. As seen in Table 17 it is mainly imported since the negligible domestic production does not cover the relatively low demands of the Greek market. Its cultivation is similar to celery and the duration of the crop from transplanting to harvest ranges from 80 to 110 days. In the case of celeriac, growers are either selling the whole plant (leaves and root), or leaves and roots separately. Each root weights around 700800 gr and yields range between 40-70 tons/ha.

1.1.21 Parsley, dill and fennel

Parsley (*Petroselinum crispum*), an indigenous species of the Mediterranean, is grown in Greece in nearly 1,000 ha, producing 22-26,000 tons. There are three types of parsley, namely, the plain-leafy type or Italian parsley (*P. crispum* var. *neapolitaneum* or *latifolium*), the curled-leafy type (*P. crispum* var. *crispum* or *filicinum*) and the turnip-rooted or Hamburg parsley (*P. crispum* var. *tuberosum* or *latifolium*). The first two types are commonly grown in Greece for their fragrant leaves, whereas turniprooted parsley is cultivated in northern Europe for both roots and leaves. Leafy parsley is harvested and sold in bunches, and prices commonly refer to a bunch, rather than a kilo of produce. It has minor economic importance, since there are virtually no imports or exports of this vegetable and farmer prices are stable throughout the year (around
0.25-0.35 € per bunch – Fig. 38).

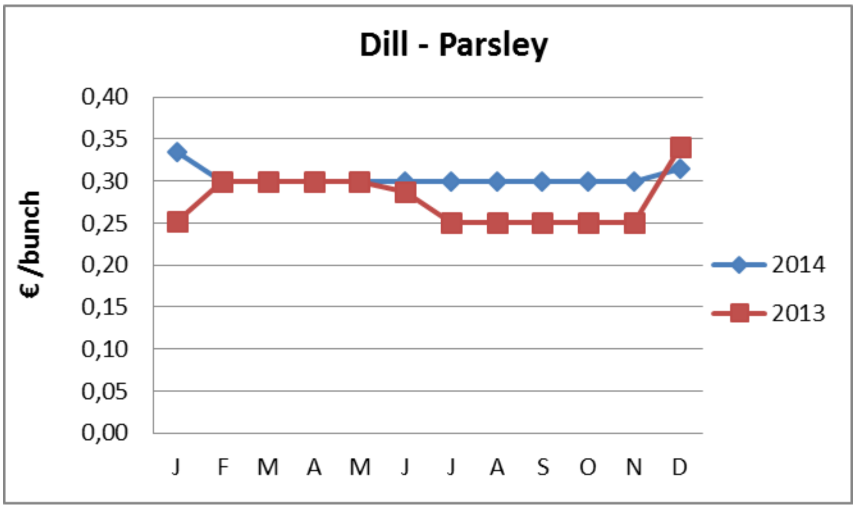


Figure 38. Seasonal variation of parsley and dill retail prices in the Central Vegetable Market of Athens, during the years 2013 and 2014.

Contrasting to the growth of the plant when harvested, parsley may stay in the field for a long period of time, usually 6-8 months, since harvesting is performed on the same plant twice, three and more times, as plants regrow after cutting, until the development of flower stalks during spring. First harvest is normally done 80-90 days after sowing (transplanting is not recommended in this crop). Yields differ much; however for leafy types may reach to 30-40 tons/ha, or 180,000-250,000 bunches/ha. The cultivation of rooted parsley in Greece could be profitable (only for exports, as parsley roots are not consumed in Greece) due to the demand from Northern European countries during winter when they cannot produce because of the frequent occurrence of frost. In this case, a grower could harvest leaves for the domestic market and roots for exports, thereby increasing the income of this crop.

Dill (*Anethum graveolens*) is also a cool-season species with minor economic importance, cultivated in 350-500 ha in Greece, in a similar way to parsley. Sweet fennel and Florence fennel or finocchio, also natives of the Mediterranean region, are cultivated in small-scale for the production of leaves (sweet fennel), of bulb-like formations of the fleshy overlapping petioles of the leaves (finocchio) or the production of seeds which are used as condiments. Fennel also has low economic importance. However, as essential oils are extracted from the leaves and especially from the seeds of those species, it could be of interest for the growers to cultivate parsley, dill and fennel for foliage during autumn-winter and also to leave plants in place in order to produce seeds during spring for additional revenue.

1.1.22 Spinach (*Spinacia oleracea)*

Spinach basically originates from Central Asia. It is cultivated mainly near urban areas. The length of the total growing period is f 35-70 days.

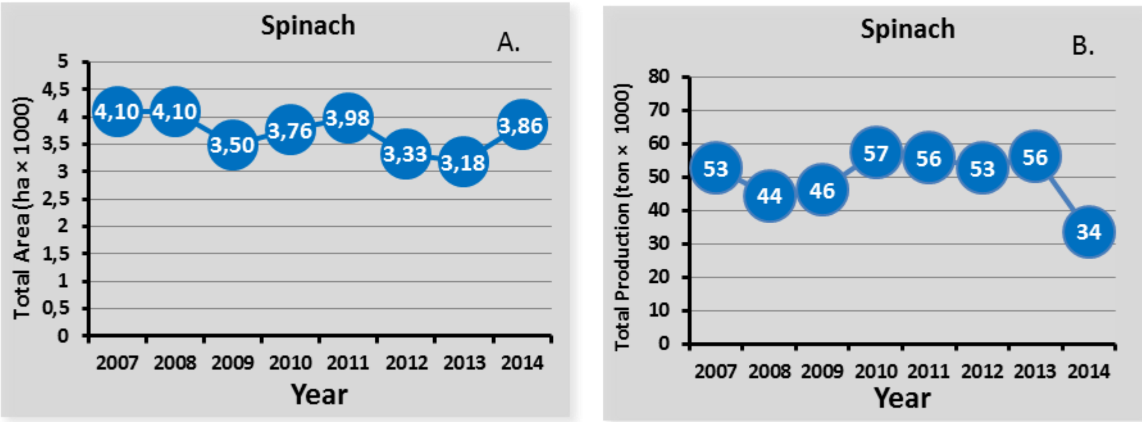


Figure 39 (A-B). Total area (A) and total production (B) of spinach cultivated in Greece during the years 2007-2014.

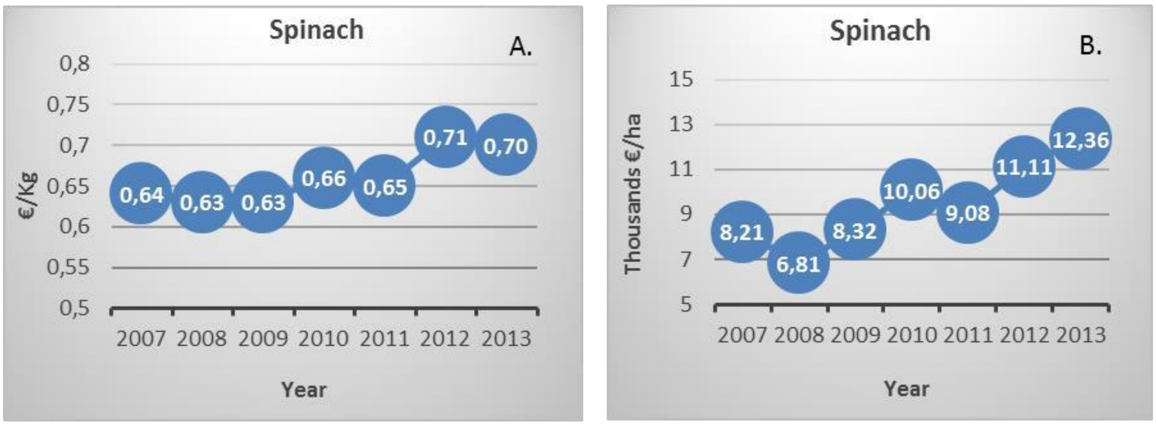


Figure 40 (A-B). Yearly average of the sales price (A) for spinach and average gross revenues (B), during the years 2007 - 2013 (data from the Greek Ministry of Rural Development and Food).

Despite the decrease in cultivated area, the total production has remained virtually unchanged in the last 7 years. The average price per kilo and the total income per hectare have shown an increasing trend between 2007 and 2013 .

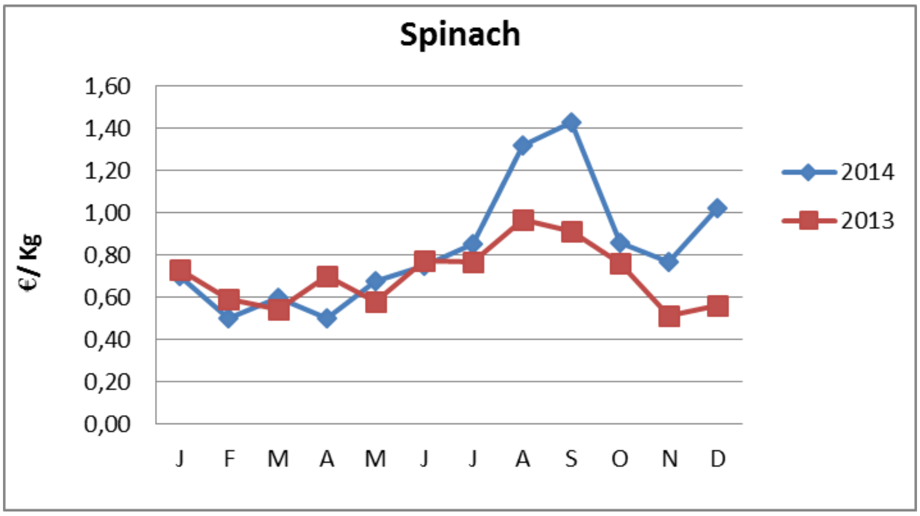


Figure 41. Seasonal variation of spinach retail prices in the Central Vegetable Market of Athens, during the years 2013 and 2014.

Main varieties spinach are Virofluy, Nobel, Achille, Geant d 'Hiver. Hybrids: Acosta, Spica, Parys. Spinach grows well in sandy loam soils rich in organic matter. Optimal pH = 6.0-7.5. It is a salt-tolerant plant. Spinach is a cool season plant, withstanding up to -9^oC, whereas the optimal growth temperature is between 16 and 20^oC.

Procedures before planting: Ploughing, milling and incorporation of manure (2030 tons /ha) and base dressing (200-300 kg 0-48-0, 300-400 kg of 0-0-48, 200-250 kg 26-0-0 per ha) are necessary. Procedures after planting: Sowing is performed in lines of 20-30cm x 10-15cm. Required amount of seed is about 20-30 kg/ha. Irrigation is applied with sprinkler irrigation system or drip irrigation system, and the amount of water required is about 3000 m^3/ha. Apply 2 or more doses of side dressing: ammonium nitrate 60-100 kg/ha. Successful weed management requires shallow hoeing or/and the application of pre-emergence herbicide (Lenacil) and post-emergence (Cycloxydin). The harvest season starts from October and lasts until May-June. The plants are pulled by hand and then washed. Then, the root is cut off about 1cm below the base of the rosette and the plants are packed in clear plastic bags. After harvest, it is necessary to wash the plants with cold water or place them in a vacuum cooler at 2,8^oC. The optimum storage conditions for spinach: 0^oC with 90-95% humidity. As far as the average yield of spinach concerned is 15-35 tons/ha.

1.1.23 Asparagus

Asparagus is an important exported vegetable for Greece as the 95 % of produced asparagus is exported abroad and mainly in the German market. Asparagus is perennial vegetable. Its harvest starts usually in the spring of the third year from its sowing. In most of the cases the plantation is used for economical production 12-15 years. Asparagus is cold season vegetable that thrives in areas with low temperatures during the vegetation and harvesting period. Thus, as shown in Table 18 most of asparagus plantations are concentrated in the northern Greece (Eastern Macedonia & Thrace) 67.9 % of the total cultivation area, followed by the Central Macedonia (22%) and Western Greece (9.8%).

As shown in Figure 42 (A) the total area of open fields cultivated with asparagus amounted to 4,230 ha in 2008 but decreased to 3,910 ha in 2010 and 2,040 ha in 2014. The total production of asparagus strongly decreased during the last 8 years from 21,680 tons in 2008 to 16,250 tons in 2010 and ended up to a yearly production of only 7,240 tons in 2014 (Fig. 42 B). The yearly average of the sales price for growers showed an increasing tendency in the years between 2009 and 2013. More specific, the average sale price for asparagus in 2007 was 1.67 € kg^{-1} followed by a stronger decrease to 1.19 € kg^{-1} in 2009 (Figure 42 C). However, the sale price of asparagus increased from 2010 to 1.31 and ended up to 2.12 € kg^{-1} in 2014, irrespective the serious economic crisis that affected the country especially during these years.

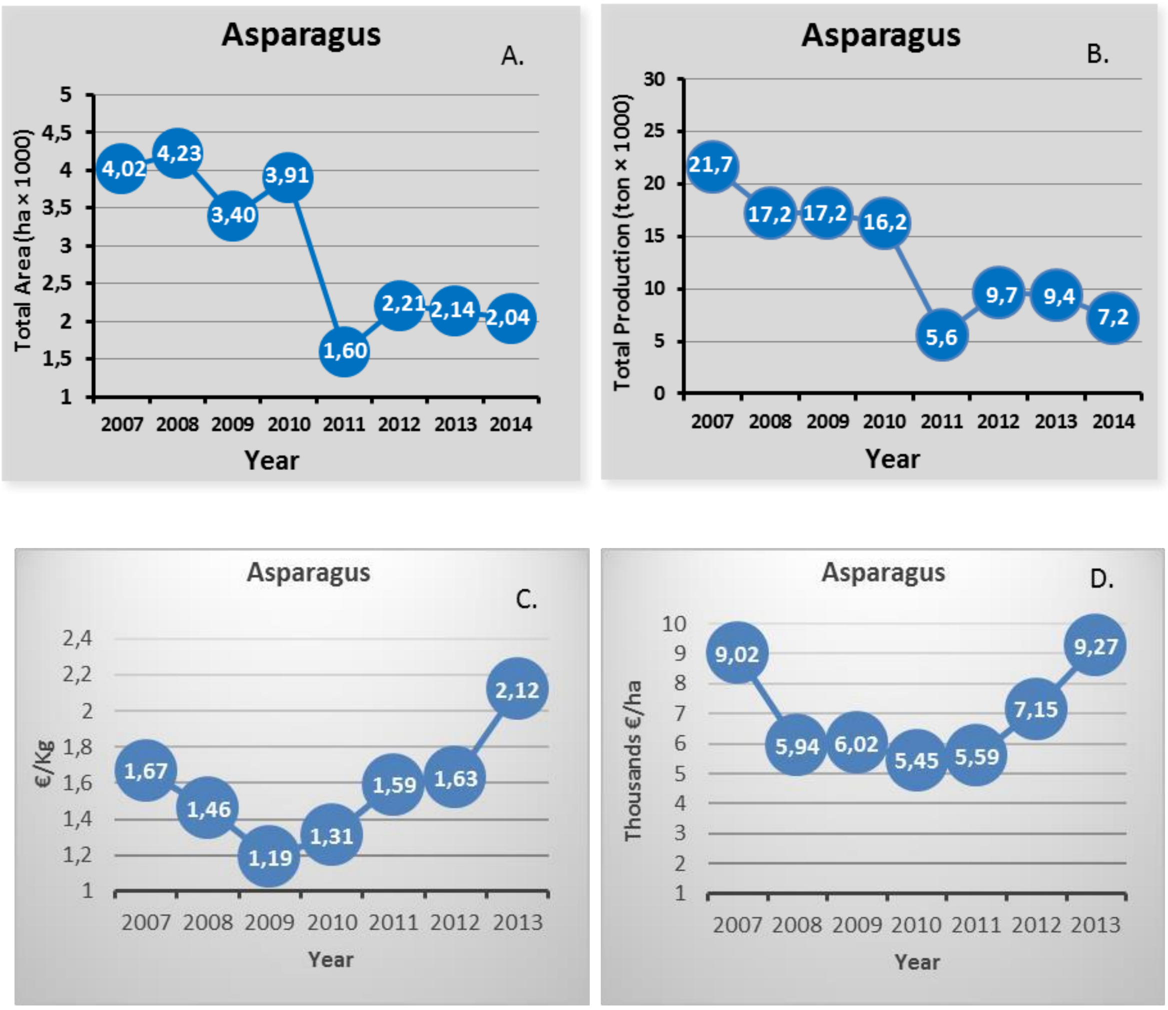


Figure 42 (A-D). Total area (A) and total production (B) of asparagus cultivated in Greece during the years 2007-2014 and yearly average of the sales price (C) for asparagus and average gross revenues (D), during the years 2007 - 2013 (data from the Greek Ministry of Rural Development and Food).

The imports of asparagus in Greece were very low and especially during summer and autumn that Greece is not producing fresh asparagus. Though, it has to be mentioned that asparagus is not included in the Greek eating habits. As far as the exports concerned a decreased was observed from 2004 to 2007 (from 16,927 tons to 13,182 tons), whereas in 2008 the total quantity of exports reached the same levels as 2004 (16,202 tons). Unfortunately, from 2009 the exports were decreased again reaching 9,551 tons in 2012.

Table 18. Cultivated area and production of asparagus in open fields allocated into the 13 regions of Greece in 2014 (data from the Greek Ministry of Rural Development and Food).

	(ha)	(%)	(ton)	(ton/ha)
Eastern Macedonia & Thrace			4,709	3.40
Central Macedonia	449	22.0	1,836	4.09

Western Macedonia	4	0.2	38	9.16
Epirus	0	0.0	2	0.00
Thessaly	0	0.0	1	3.20
Ionian Islands	0	0.0	0	0.00
Western Greece	200	9.8	650	3.25
Central Greece	1	0.0	10	10.11
Attica	0	0.0	0	0.00
	1,385	67.9		
Region	Total area		Total production	Mean production
Peloponnese	0	0.0	0	0.00
North Aegean Islands	0	0.0	0	0.00
South Aegean Islands	0	0.0	0	0.00
Crete				
Total	2,039	100	7,246	
	0	0.0	0	0.00
				3.55

Table 19. Quantities and values of imported and exported asparagus during the years 2003-2012 in million € and tons, respectively (ELSTAT).

Year	Imports		Exports	
	Tons	million €	Tons	million €
2003	246	0.51	16,247	28.25
2004	814	1.4	16,927	33.21
2005	873	1.5	13,033	29.17
2006	948	1.51	14,116	36.49
2007	1,004	2.41	13,182	33.26
2008	715	1.08	16,202	37.81
2009	235	2.98	11,074	23.62
2010	1,294	2.66	13,023	29.43
2011	1,334	2.08	8,967	19.24
2012	1,064	2.23	9,551	21.46
Mean	853	1.84	13,232	29.19

Greek asparagus is a competitive exported vegetable that can be more strengthen increasing the product quality as well as the earliness of the product as these are the two main parameters that define the final sale price in the market abroad. Grower's aim is to harvest asparagus as soon as possible as this is the basic characteristic and advantage of Greek asparagus. However, Greek growers highlight the importance to promote Greek asparagus in other markets abroad except Germany like Italy and Switzerland. The creation of organized groups of farmers can play significant role to this direction and at the same type can reduce the cost production.

1.1.24 Carrot (*Daucus carota* var. *sativus*)

Carrot is the most economically important species of the Apiaceae family and globally is ranked third among vegetables grown for underground organs. As shown in Fig. 43 (A, B), carrot is cultivated in large areas in Greece and production is virtually stable the last 8 years. It must be noted however, that cultivated areas and production

are seriously increased from 2006 onwards, as until 2006 carrot was grown in less than
1200 ha and total production reached up to 36,000 tons. This is due to an increase in demand from domestic market and also due to higher exports. The last few years increased demand has positively affected carrot prices, as farmers prices substantially increased during 2012 and 2013, both per kg of produce and per cultivated area.

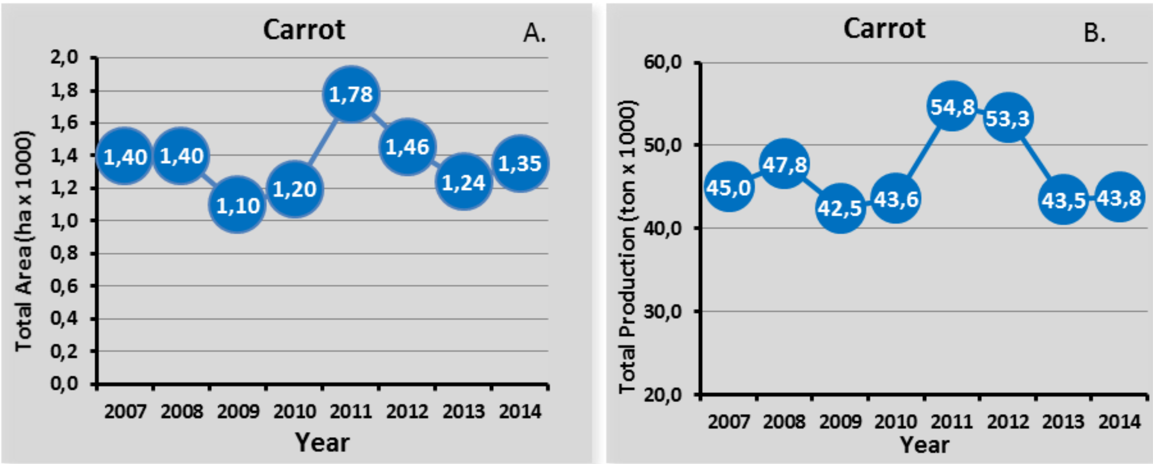


Figure 43. Total area (A) and total production (B) of carrot cultivated in Greece during the years 2007-2014.

Despite the increase in production, Greece imports large quantities of carrot (Table 20); however the last 7 years exports are significantly raised so as in 2012 exports exceeded imports in quantity, but were far less in value. We import carrots from Germany, Belgium, Holland and Italy, whereas we export mainly to Bulgaria and Romania and to a lesser extend to Cyprus and United Kingdom. As the demand for carrot in foreign markets is high, there is a continuous interest for exports to Central and Northern European countries as well. In addition, the last few years there is also an increasing interest of the markets for "baby" and minimally processed carrots (e.g. sliced for snacks, in fresh-cut salads etc.). Therefore, carrot production in Greece seems promising provided there are serious efforts from Greek producers, retailers and wholesalers to organize marketing and distribution of those products to foreign markets.

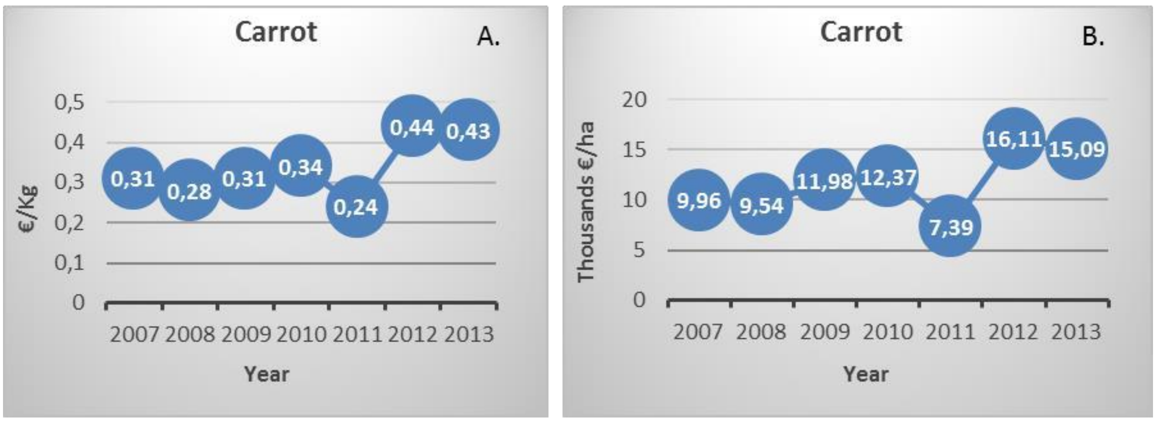


Figure 44. Yearly average of the sales price (A) for carrot and average gross revenues (B), during the years 2007 - 2013 (data from the Greek Ministry of Rural Development and Food).

Table 20. Imports and exports, in quantity (tons) and value (1000 €) of carrot in Greece, over the years 2003-2012.

YEAR	Imports		Exports	
	Quantity (Tons)	Value (1000 €)	Quantity (Tons)	Value (1000 €)
2003	4,144	1,440	687	140
2004	1,794	826	110	25
2005	3,858	112	693	148
2006	3,759	1,759	887	156
2007	3,938	1,729	438	131
2008	3,857	2,040	2.367	556
2009	3,727	1,907	2.363	743
2010	3,698	2,192	2.437	524
2011	4,407	2,145	2.705	727
2012	3,091	1,717	4.362	992

Carrot is a cool-season species, and in Greece it is sown during autumn (September-October) in areas with mild winter for production during spring, whereas in colder areas it is commonly sown in spring for production during summer. Carrot can be readily stored under low temperatures for 6-9 months; therefore it is available in markets throughout the year. A relative shortage might be observed during early spring, or in the case of harsh winters, during early summer, thereby increasing prices (Fig. 45). The main regions of carrot production in Greece are the Prefectures of Boeotia (accounts for 35% of the total cultivated in Greece), Euboea (27%), Thessaloniki (16%) and Attica (6.5%).

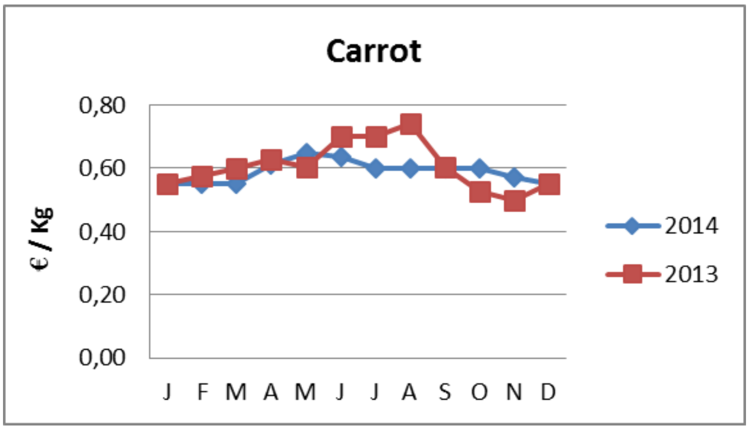


Figure 45. Seasonal variation of carrot retail prices in the Central Vegetable Market of Athens, during the years 2013 and 2014.

Carrot crop is not particularly demanding. It grows best under average temperatures between 16-20°C, tolerates low temperatures but under 10°C growth is inhibited, roots do not develop sufficient color and there is increased possibility for bolting. Carrot plants do not grow well above 29°C as well. Although they may grow in various soil types, deep, well cultivated soils are preferred, otherwise upper parts of the roots grow above soil level and develop "green shoulders". Carrots are not heavy feeders and are not also demanding in irrigation, which in most of the cases is done by sprinklers. However, root quality is ensured when frequent irrigation is applied with good quality water of low EC. Due to dense planting (100-150 plants/m^2) and the large number of plants per ha, propagation is done by direct sowing, although carrot seeds do not have high germinability (65-85%) and seedling emergence in the field is usually not uniform.

Carrots can be harvested after 80-150 days from seeding, depending on the variety, the season and the temperatures during plant growth. In small areas harvest is done usually after irrigation, by pulling plants from their leaves. In large areas mechanical harvest is preferred, but it may cause serious injuries to roots. Carrots in the market are either sold with or without a part of the leaves. Leaf removal results in less loss of water from roots during storage and distribution to the markets, but indicates freshness of the products. When carrots are to be stored for a longer time, leaves are removed. Yields in Greece are satisfactory compared to other countries and typically range between 25-60 tons/ha, at an average of 40 tons/ha.

1.1.25 Beetroot (*Beta vulgaris* var. *crassa*)

Beetroot, a cool-season crop is commonly cultivated for the succulent tap roots; although leaves are also produced and may consumed together with the roots, in all temperate areas. In Europe it is widely grown and consumed in Germany and France. In Greece, beetroot cultivated areas and production are rather stable the last years (Fig. 46), following the same trend of the last 20 years. Farmer prices are similarly stable (Fig. 46). The domestic production does not cover the needs of Greek market; hence 500-100 tons/year are imported mainly from Germany and Italy. The last decade there are also imports of ready to eat boiled beetroots in plastic bags under vacuum, mainly from France, which are sold in supermarkets.

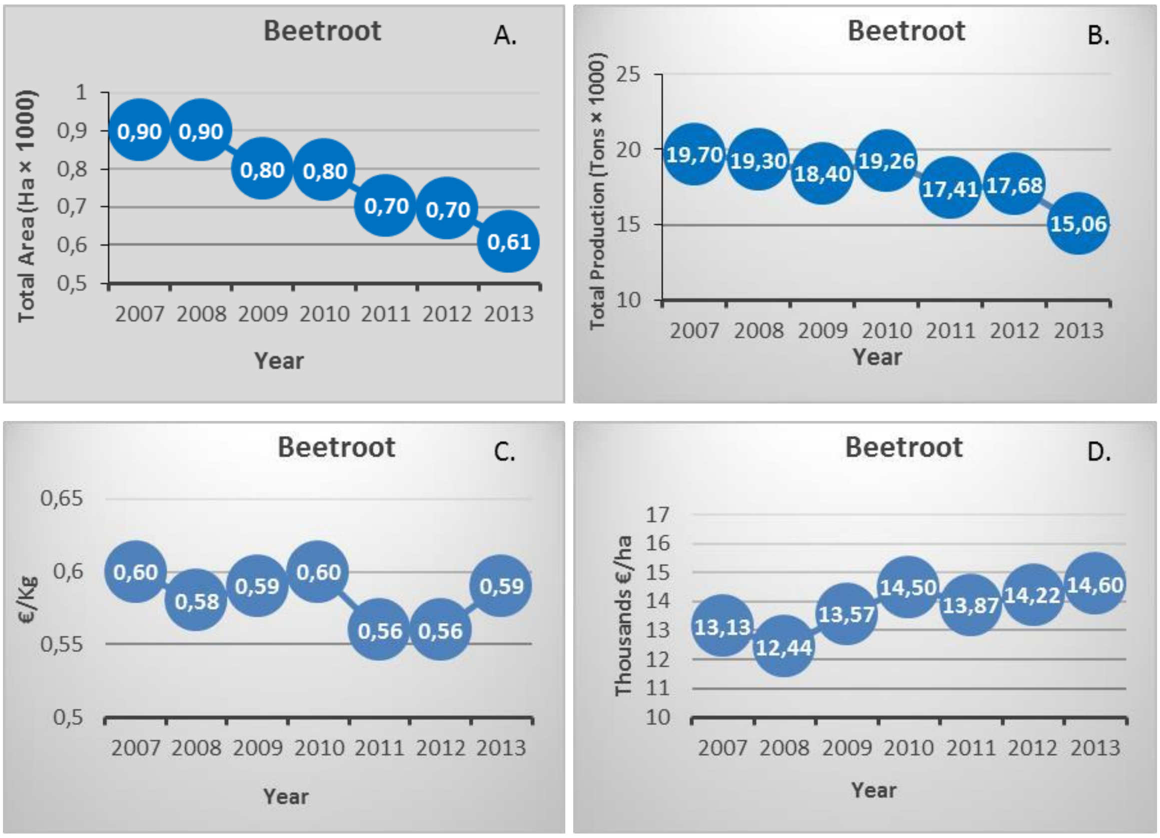


Figure 46 (A-D). Total area and total production of beetroot cultivated in open fields in Greece during the years 2007-2013 and yearly average of the sales price for beetroot and average gross revenues, during the years 2007 - 2013 (data from the Greek Ministry of Rural Development and Food).

As beetroot is a non-perishable vegetable which can be stored for long (up to 4-6 months under cool storage) and withstands handling and transportation (when is sold without leaves), exports of Greek beetroot when there is a shortage in Northern European countries during winter, could be feasible. This, in combination with the insufficiency in the domestic market, could lead to an increase of beetroot cultivation in our country.

Beetroot plants prefer slightly alkaline soils (can be cultivated even at pH 10) and are particularly tolerant to water and soil salinity, as EC up to 4.0 dS/m does not have an effect on yield. Therefore, areas unsuitable for other vegetable crops (e.g. alkaline and saline soils which largely occur in Greece) could be utilized by beetroot cultivation. On the other hand, it grows well during winter, withstands light frost, prefers average temperatures between 14-20°C but cannot withstand heat. Beetroot should preferably grow in sandy, sandy-loam, deep soil, which drains well, as heavy, clay soils cause root deformation. It is not particularly demanding in macro-elements in the soil, but is susceptible in deficiencies of microelements, such as B, Fe, Mn, Cu and Mo. It is also not demanding in irrigation, but at early autumn and spring cultivation due to the large leaf area, it needs irrigation every 3-4 days for untroubled root development.

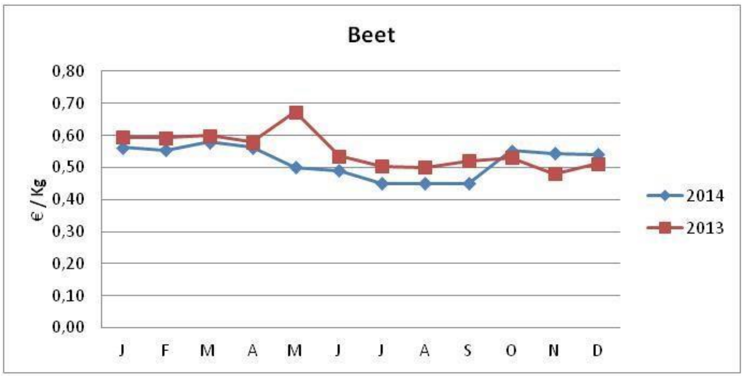


Figure 47. Seasonal variation of beetroot retail prices in the Central Vegetable Market of Athens, during the years 2013 and 2014.

2.1 Greenhouse vegetable production

1.2.1. Greenhouse bean

In recent years, there is an interest in the cultivation of common beans in greenhouses in order growers to provide out off season product in the market and achieved a better price. Besides this, it has to be mentioned that many growers because of the financial problems that are dealing during the last years of the Greek crisis select to cultivate early green bean in greenhouse instead of high cost crops as tomato. However, the field-grown green bean continues to occupy the biggest part of the total cultivated area regarding green bean in Greece, as its demand is substantially increased during the summer months.

As shown in Table 21, the leading region in domestic production of green bean in greenhouses is Western Greece and Central Macedonia with nearly more than half of the total production (approximately 60%), followed by Peloponnese and Crete.

Table 21. Cultivated area and production of bean in Greek greenhouses allocated into the 13 regions of Greece in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area (ha)	Total area (%)	Total production (ton)	Mean production (ton/ha)
Eastern Macedonia & Thrace	4	1.0	61	15.06
Central Macedonia	118	29.0	2,485	21.12

Western Macedonia	0	0.1	15	37.50
Epirus	16	3.8	381	24.44
Thessaly	10	2.5	117	11.67
Ionian Islands	0	0.1	0	1.00
Western Greece	124	30.7	3,054	24.56
Central Greece	3	0.8	37	11.31
Attica	9	2.2	27	0.00
Peloponnese	68	16.8	1,838	26.96
North Aegean Islands	4	0.9	26	7.22
South Aegean Islands	2	0.6	86	35.92
Crete	47	11.6	1,748	37.25
Total	**406**	**100**	9,876	24.35

Green beans can be cultivated in the greenhouse during two cultivation periods; from the early December with harvesting season to start in the end of January and ceases in March and from September with the harvesting season to start in late October and ceases in the end of November. Nevertheless, there are also some late cultivations of green bean whereas the harvesting season comes to an end in the middle of June. It has to be mentioned that heating is an essential requirement especially in the early cultivation of green bean that starts in December and will increase the cost. This is why areas of production with mild winter (such as Northern Greece and Crete) are suitable choices for early production of been in greenhouse to reduce heating costs.

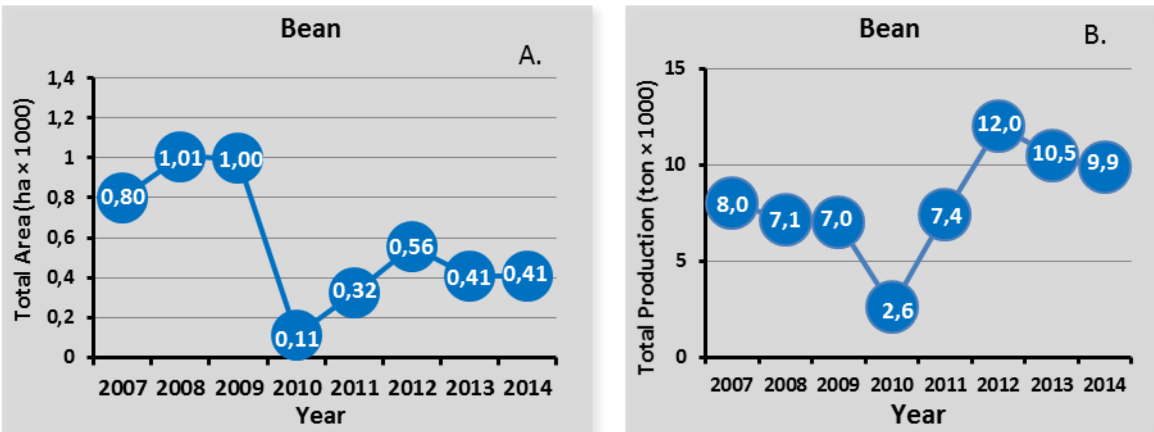


Figure 48 (A-B). Total area and total production of green beans cultivated in greenhouses in Greece during the years 2007-2014.

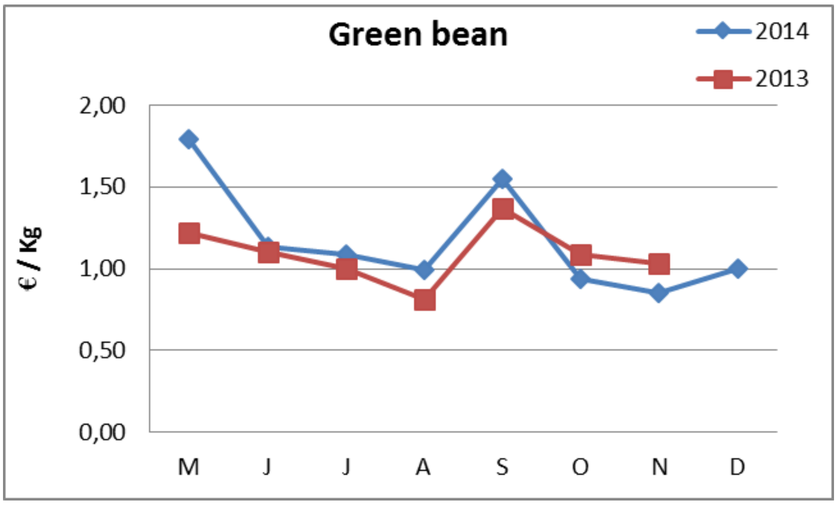


Figure 49. Seasonal variation of green bean retail prices in the Central Vegetable Market of Athens, during the years 2013 and 2014.

1.2.2. Greenhouse cucumber

Cucumber is the second most important greenhouse vegetable in Greece. Two groups of cucumber cultivars are cultivated in the Greek greenhouses, i.e. the long-fruit type, which are partly intended for the export, and the short-fruit type. As shown in Figure 50, the total greenhouse area cultivated by cucumber fluctuated from 1,190 to 1,840 ha with a mean value of 1,441 ha. At the same time, the total greenhouse area ranged from 5,100 to 5,650 ha with a mean value of 5,400 ha. It is estimated that the greenhouses cultivated with cucumber correspond on average to 24% of the total greenhouse area in Greece.

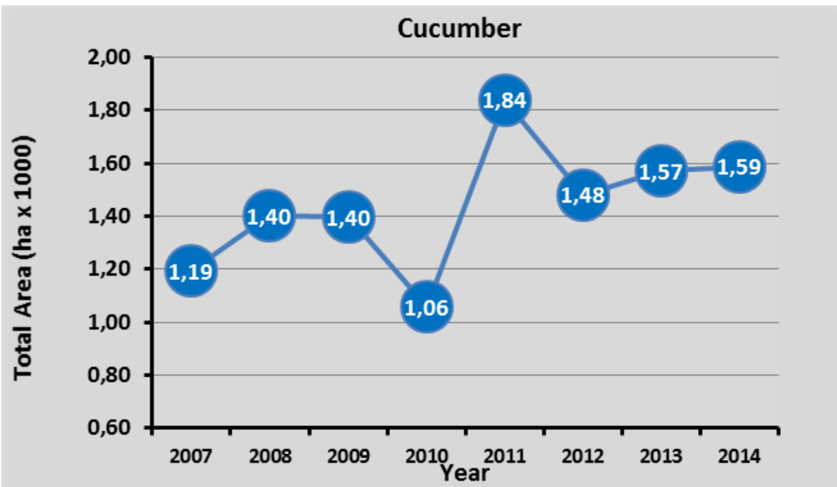


Figure 50. Evolution of the greenhouse area cultivated with cucumber in the years 2007-2014.

The total cucumber production in the Greek greenhouses during these years ranged from 97 to 185 tons with an average of 144,65 (Figure 51). These data render a yield ranging from 97 to 185 ton ha^{-1} with an average of 145 ton ha^{-1} during these years. The above-referenced values are statistical means from both long-fruit and short fruit types of cucumber. When comparing the long- and short-fruit types, it becomes obvious that the long-fruit types of cucumber provide slightly higher yields than the short-fruit cultivars. The above referenced values are statistical means which are derived by including also the yield performance obtained in very simple constructions (e.g. high tunnels). However, the potential yield of cucumber in a typical unheated greenhouse in Creta with a plant density of about 1.8 plants m^{-2} ranges from 7 to 10 fruit per m^2 per month for long-fruit types and from 14 to 18 fruit for short-fruit types. To extrapolate from fruit number to fruit weight, a mean fruit weight of about 340-400 g for long-fruit types and 140-180 for short-fruit types has to be taken into consideration. Thus, the potential yield of a cucumber crop in unheated greenhouses is estimated to about 3.5 kg per m^2 per month for long-fruit types and 3.2 kg per m^2 for short-fruit types. As a total, a yield potential of 170 to180 ton ha^{-1} is estimated for a long-fruit cucumber crop grown in an unheated Cretan greenhouse for a five-month production period. The corresponding value for a short-fruit cucumber crop is about 150 to 160 ton ha^{-1}. Nevertheless, this level of production is much lower than that obtain in fully equipped glasshouses in Northern Europe (i.e. the Netherlands), because most Greek greenhouses used for out of season cucumber production are not heated.

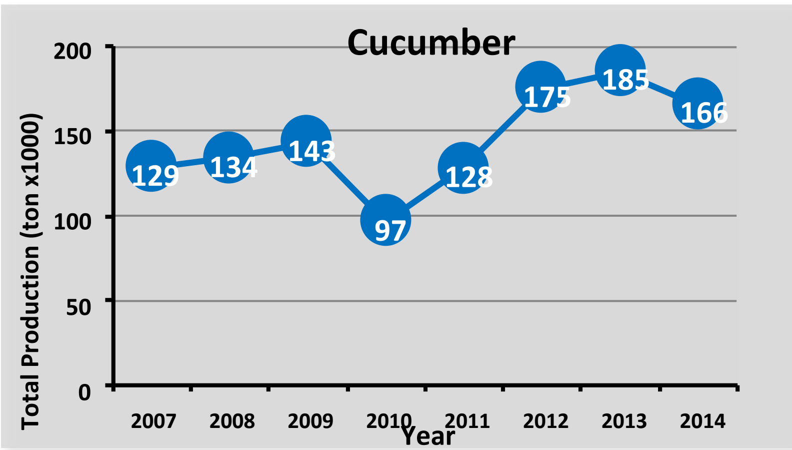


Figure 51. Evolution of total cucumber production in Greek greenhouses during 20072014.

Despite the low yield obtained per unit of cultivated area, production of acceptably good quality cucumbers in unheated greenhouses is possible in southern Greece and especially in Crete, because the fruit develop parthenocarpically and thus fruit set is not depending on high temperatures for sufficient pollen production and germination.

The geographical distribution of the total greenhouse area cultivated with cucumber to the 13 Regions of Greece and the corresponding production in each region are shown indicatively for 2014 in Table 22. As shown in Table 22, Crete is leading in greenhouse cucumber production with more than half of the total greenhouse area cultivated with cucumbers (53.1%), followed by Peloponnese (13.4%) and Central Macedonia (10.1%). The mild climate of Crete and southern Peloponnese, which allows out-of season cultivation in unheated greenhouses, is the predominant reason for the leading position of these regions in greenhouse cucumber.

Table 22. Cultivated area and production of cucumber in Greek greenhouses allocated into the 13 regions of the country in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area (ha)	(%)	Total production (ton)	Mean production (ton/ha)
Eastern Macedonia & Thrace	15	0.9	735	48.94
Central Macedonia	161	10.1	12,291	76.27
Western Macedonia	3	0.2	50	19.12
Epirus	108	6.8	15,651	145.46
Thessaly	9	0.5	945	108.87
Ionian Islands	2	0.1	25	11.98
Western Greece	72	4.5	7,120	98.89
Central Greece	13	0.8	667	52.05
Attica	59	3.7	320	5.41
Peloponnese	213	13.4	41,843	196.23
North Aegean Islands	10	0.6	772	80.42
South Aegean Islands	81	5.1	2,004	24.67
	843	53.1		
Total	1,588	100		
Crete			83,360	98.90
			165,782	104.40

The mean yearly wholesale prices of cucumber in the years from 2007 to 2012 are shown in Figure 52. Furthermore, the fluctuation of the monthly wholesale prices of cucumber during the years 2013 and 2014 are illustrated in Figure 53. The data shown in Figure 4 clearly show that cucumber achieves high prices mainly in the cold-season months, particularly from December to February or March. These months coincide with the season of the year that is characterized by very low light levels in Northern Europe which make production of cucumber in greenhouse economically not viable during that time. Therefore, production of greenhouse cucumber in northern Europe and especially in the Netherlands ceases during these months and this provides good opportunities to Greek greenhouse growers for exports. Indeed, Greece exports considerable amounts of cucumber from November to March every year, as indicated by the Greek imports and exports of cucumber in the last ten years, which are shown in Table 23. The exports and the lack of competitive cucumber production from the field during these months contribute to a significant increase in the prices offered to the growers during this period.

Another conclusion derived from Figure 53 is that the short-fruit type cucumber achieves higher prices in the wholesale market. However, the long-fruit cucumber is exported during November - March at prices that are higher than those achieved in the local wholesale markets. Nevertheless, the short cucumber is very popular in Greece and its production in the greenhouse is becoming increasingly attractive for greenhouse growers. Today, gynoecious cucumber hybrids that set fruit parthenocarpically are available also for short-fruit types. The short-fruit types of cucumber provide only slightly lower yields that the long-type cultivars. Thus, the cultivation of short-fruit types of cucumber is expected to increase in the coming years.

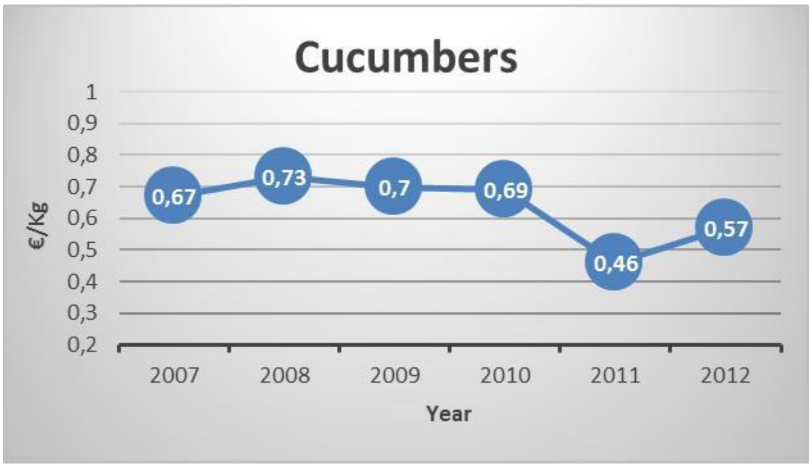


Figure 52. Mean yearly prices paid to growers for fresh-market cucumber during 2007 – 2012 at the Athens Central Fresh Fruit and Vegetable Wholesale Market.

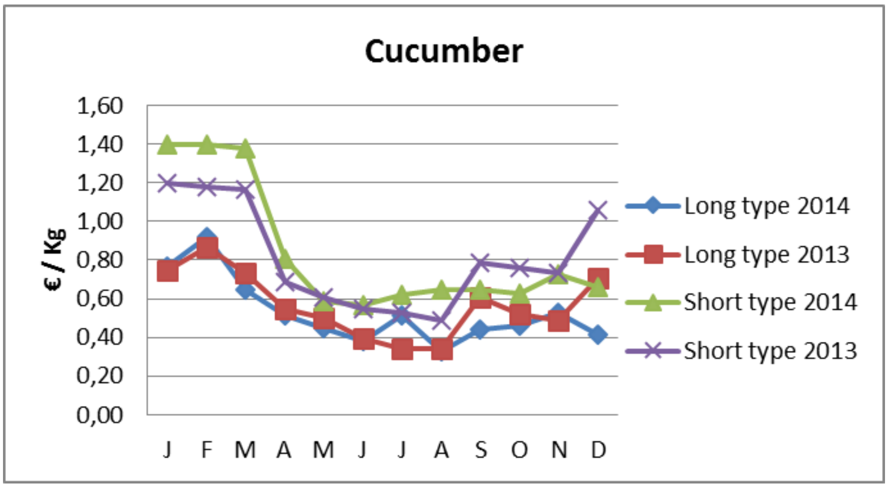


Figure 53. Mean monthly prices for fresh-market cucumber (long- and short-fruit types) during the years 2013 and 2014 at the Thessaloniki Central Fresh Fruit and Vegetable Wholesale Market.

Table 23. Amounts and values of imported and exported cucumber in the last 10 years in Greece (Olympios, 2015).

Year	Imports		Exports	
	Tons	million €	Tons	million €
2003	4,735	2.65	23,775	28.22
2004	5,809	2.71	23,087	19.49
2005	2,596	2.09	20,170	25.31
2006	2,301	1.80	24,473	25.08
2007	1,784	2.12	21,697	20.20
2008	1,526	1.59	20,742	18.17
2009	899	1.26	17,564	21.28
2010	689	0.73	29,354	28.49
2011	523	0.58	26,178	19.32
2012	485	0.50	30,668	29.16
Mean	2,135	1.60	23,771	23.47

The production cost of cucumber in greenhouses is similar with that of tomato in unheated greenhouses. In heated greenhouses the heating cost for cucumber is slightly lower, because cucumber fruit is parthenocarpic and thus, fruit set and quality are less depending on optimal temperatures. Also bumblebees for publication are not needed in greenhouse cucumber crops. On the other hand, greenhouse cucumber crops are more prone to diseases and require a higher expenditure for plant protection. Nevertheless, since the cost for greenhouse cucumber production is similar or slightly lower than that of tomato while the selling prices are more or less comparable, cucumber will remain an important greenhouse crop in the next years.

1.2.3. Greenhouse eggplant

The greenhouse crops of eggplant in Greece account for only 9-13% of the total area cultivated with this fruit vegetable, but deliver over one third of the total domestic production. Thus, for instance, in 2012, the total and the greenhouse area cultivated with eggplants were 2,298 and 300 ha, respectively, while the total and the greenhouse production of eggplant fruit were and 77, 282 and 25,885 ton, respectively. The greenhouse area cultivated with eggplants and the total production obtained from this area are shown in Figure 54 A,B. This discrepancy between the contribution of greenhouses to the total cultivated area and the total production of eggplants points to a much higher yield performance in greenhouses than in the open field. Indeed, the average yield of fresh eggplant fruit in greenhouses ranged from 18.5 to 27.3 tons ha^{-1} in the years between 2007 and 2012. Nevertheless, the yield performance recorded in the last years in greenhouses cultivated with eggplant is much lower than that reported for the Dutch greenhouses (25 ton ha^{-1} according to FAOSTAT 2012).

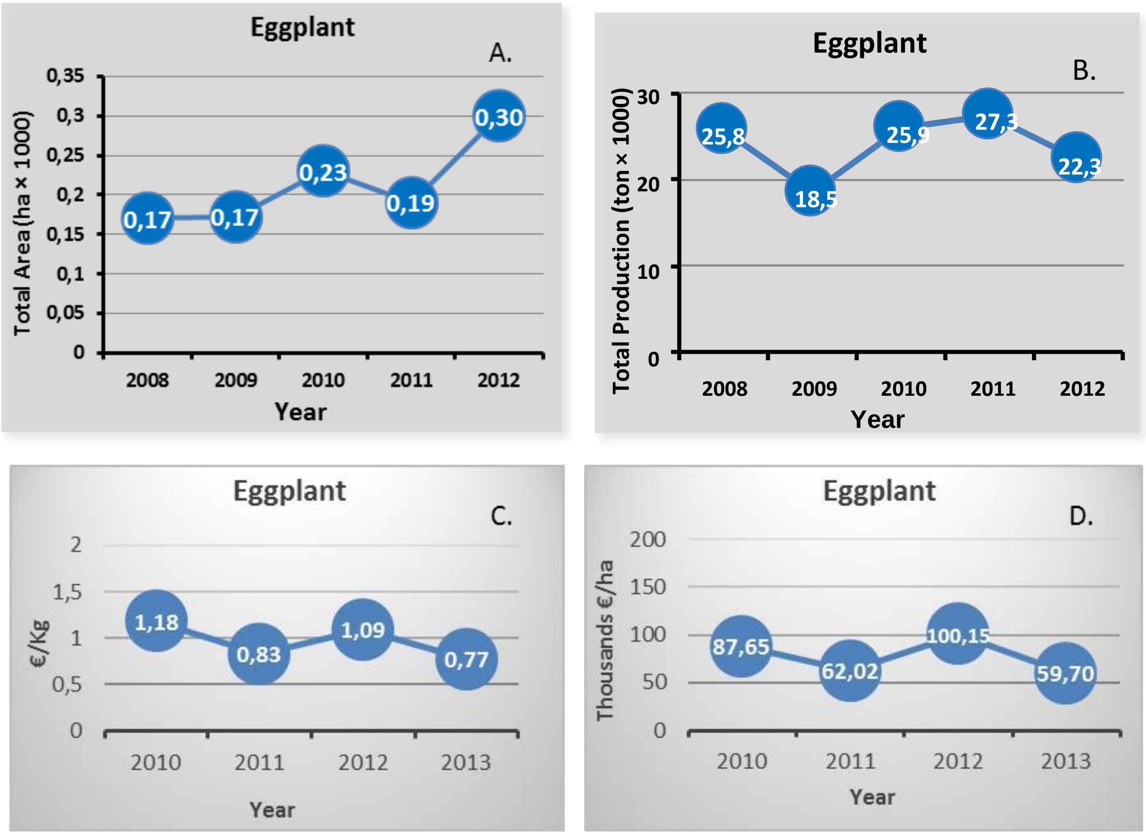


Figure 54 (A-D). Total area (A) and total production (B) of eggplant cultivated in Greek greenhouses during the years 2008-2012 and the yearly average of the sales price (C) for eggplant and average gross revenues (D), during the years 2010 - 2013 (data from the Greek Ministry of Rural Development and Food).

To improve the yield performance of eggplant crops in the Greek greenhouse, extension of the cultivation period, and improved climate control with emphasis on maintenance of proper temperature levels are recommended. As already reported in the survey on field-grown eggplant, this Solanaceae vegetable is a warm season plant with an optimum temperature for production that ranges between 22-30 °C during the day and 18-24 ºC during the night. Thus, to successfully grow eggplant in greenhouse and get satisfactory yields, a minimum temperature of 20 °C is needed during the day in the winter. On the other hand, a temperature difference of at least 4 °C but preferably 5 °C or higher between day and night is needed for optimal fruit setting. Thus, the night temperature should be adjusted to levels depending on the anticipated mean day temperature, so as to maintain the above-mentioned temperature difference between day and night, and at any case at higher levels than 16 ^{o}C.

The geographical distribution of the total greenhouse area cultivated with eggplant to the 13 Regions of Greece and the corresponding production in each region are shown indicatively for 2014 in Table 24. As shown in Table 24, Crete is leading in greenhouse eggplant production with almost half of the total greenhouse area cultivated with cucumbers (48.5%), followed by Peloponnese (21.3%) and Central Macedonia (15.4%). The mild climate of Crete and southern Peloponnese, which allows out-of season cultivation in unheated greenhouses, is the predominant reason for the leading position of these regions in greenhouse eggplant, while Central Macedonia provides the advantage of being close to the large consumption center of Thessaloniki.

Table 24. Cultivated area and production of eggplant in Greek greenhouses allocated into the 13 regions of the country in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area (ha)	(%)	Total production (ton)	Mean production (ton/ha)
Eastern Macedonia & Thrace	4	1.2	78	18.15
Central Macedonia	55	15.4	2,018	36.67
Western Macedonia	2	0.5	56	30.83
Epirus	11	3.1	541	48.19
Thessaly	4	1.0	99	27.26
Ionian Islands	1	0.3	2	2.22
Western Greece	12	3.4	502	41.83
Central Greece	1	0.2	8	12.73
Attica	8	2.1	65	0.00
Peloponnese	76	21.3	2,718	35.85
North Aegean Islands	2	0.4	64	40.00
South Aegean Islands	9	2.5	148	16.43
Crete	173	48.5	16,010	92.48
Total	357	100	22,310	62.56

The mean yearly wholesale prices of greenhouse-produced eggplant in the years from 2007 to 2013 are shown in Figure 54 C. Furthermore, the fluctuation of the monthly wholesale prices of eggplant during the years 2013 and 2014 has been shown in Figure 8, when reporting on field-grown eggplant. The data shown in Figure 8 clearly show that eggplant achieves high prices mainly in the cold-season months, particularly from December to February or March. The production cost of eggplant per cultivated area unit in greenhouses is slightly lower than that of tomato. However, the yield potential of eggplant is normally about 60% of that anticipated in tomato crops; thus the production cost per kg of eggplant fruit is somewhat higher than that of tomato. Nevertheless, the monthly averages in the sales prices of eggplant are substantially higher than those of tomato with the exception of the summer months.

Thus, the slightly higher production cost of eggplant per kg is partly offset by the substantially higher sales price. Consequently, the production of eggplant in greenhouses, especially during the winter months, leaves a satisfactory profit margin to growers.

1.2.4. Greenhouse melon

The cultivation of melon in tall greenhouses accounts for only a small part of the total melon production. Unfortunately, the Greek Ministry of Rural Development and Food (MRDF) could not provide data about cultivation in low tunnels, high tunnels, and greenhouses, for 2013 and 2014, and thus, all melon crops in low tunnels are registered as "protected cultivation" in these years. According to the currently available data of MRDF for 2014, the "protected cultivation" of melon occupies 686 ha, which corresponds to 14,4% of the total area cultivated with melon in Greece. Nevertheless, only a small part of this area corresponds to high tunnels or other types of greenhouses. Indeed, according to older data of the MRDF, only 123,2 ha of tall greenhouses were cultivated with melon in 2012, and in most of them melon was the second crop during the same year, with tomato or cucumber being the first crop in most cases.

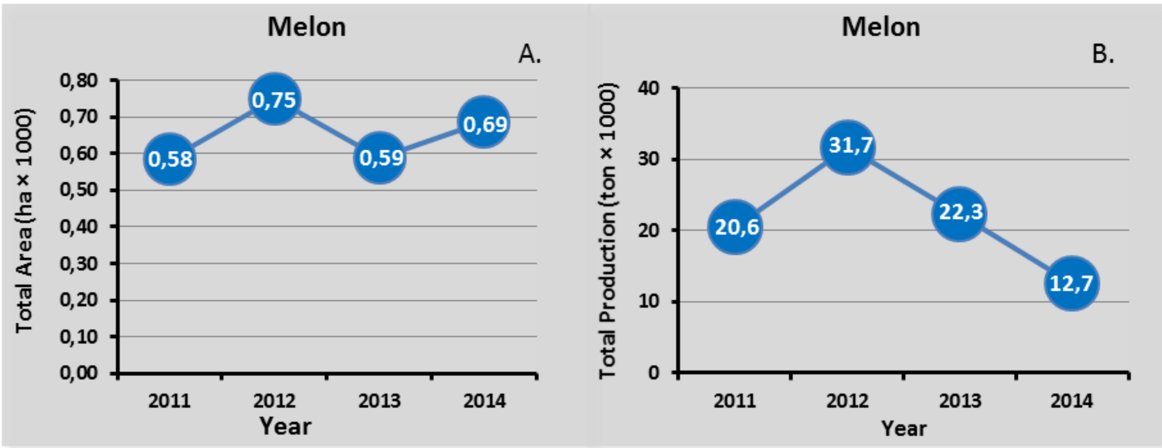


Figure 55 (A-B). Total area (A) and total production (B) of melon cultivated in Greek greenhouses during the years 2011-2014.

Taking into consideration the geographical distribution of melon cultivation in low tunnels, high tunnels, and greenhouses, which is shown indicatively for 2014 in Table 25, the leading region in field watermelon cultivation is Western Greece with 31.4%, of the total area, followed by Central Macedonia with 22.2%. Other important centers of melon cultivation in low tunnels, high tunnels, and greenhouses are Eastern Macedonia and Thrace with 14.6%, Crete with 14.0% and Thessaly with 13.5% .

Melon is a warm-season vegetable with relatively high temperature requirements. Cultivation in high tunnels or greenhouses is aimed at producing early melon in April and May, which is recouped with high selling prices. However, the currently very low exports of Greek melon indicate a need to produce even earlier in greenhouses. Actually, a further increase of melon cultivation in greenhouses should focus mainly on winter and early spring production. Exports to elite markets in north European countries at that time might recoup the heating cost. Nevertheless, a thorough market analysis in potential export countries is needed to examine this possibility.

Table 25. Cultivated area and production of melon in Greek greenhouses allocated into the 13 regions of Greece in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area (ha)	(%)	Total production (ton)	Mean production (ton/ha)
Eastern Macedonia & Thrace	100	14.6	6	0.06
Central Macedonia	153	22.2	37	0.24
Western Macedonia	0	0.0	0	0.00
Epirus	5	0.7	37	0.00
Thessaly	93	13.5	2,554	27.53
Ionian Islands	2	0.3	0	0.00
Western Greece	215	31.4	2,900	13.47
Central Greece	3	0.4	135	0.00
Attica	0	0.1	0	0.00
Peloponnese	9	1.4	224	24.02
North Aegean Islands	8	1.2	350	41.42
South Aegean Islands	2	0.3	0	0.00
Crete	96	14.0	6,436	67.10
Total	686	100	12,679	18.48

1.2.5. Greenhouse pepper

Pepper is the third most important greenhouse vegetable in Greece after tomato and cucumber. Four groups of sweet pepper cultivars are cultivated in the Greek greenhouses, i.e. the Sweet Charleston type, which are partly intended for the export, the Blocky type, the Florina pepper and the Sweet Bell type. The greenhouse crops of pepper in Greece account for only 9,8 % of the total area cultivated with this fruit vegetable. Thus, for instance, in 2014, the total and the greenhouse area cultivated with pepper were 4,224 and 1,089 ha, respectively, while the total and the greenhouse production of pepper fruit were 147,908 and 92,624 ton, respectively.

The greenhouse area cultivated with pepper and the total production obtained from this area are shown in Figure 56. This discrepancy between the contribution of greenhouses to the total cultivated area and the total production of pepper points to a much higher yield performance in greenhouses than in the open field. Indeed, the average yield of fresh pepper fruit in greenhouses ranged from 67.6 to 93.5 tons ha^{-1} in the years between 2007 and 2014, while in open field the corresponding range was from 15.51 to 22.17 tons ha^{-1}. As shown in Figure 56, the total greenhouse area cultivated by pepper fluctuated from 570 to 1,150 ha with a mean value of 990 ha. At the same time, the total greenhouse production ranged from 48,200 to 92,620 tons with a mean value of 80,490 ha (Figure 56 B).

Table 26. Cultivated area and production of pepper in Greek greenhouses allocated into the 13 regions of Greece in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area (ha)	(%)	Total production (ton)	Mean production (ton/ha)
Eastern Macedonia & Thrace	39.44	3.6	2,107.40	53.43
Central Macedonia	243.72	22.4	14,760.44	60.56
Western Macedonia	11.05	1.0	175.00	15.84
Epirus	17.40	1.6	491.80	28.26
Thessaly	12.54	1.2	482.80	38.50
Ionian Islands	1.05	0.1	1.98	1.89
Western Greece	36.21	3.3	660.00	18.23
Central Greece	1.67	0.2	20.00	11.98
Attica	3.67	0.3	0.00	0.00
Peloponnese	87.32	8.0	6,248.70	71.56
North Aegean Islands	1.41	0.1	56.00	39.72
South Aegean Islands	9.63	0.9	245.30	25.47
Crete	623.91	57.3	67,375.00	107.99
Total	1,089.02	100	92,624.42	85.05

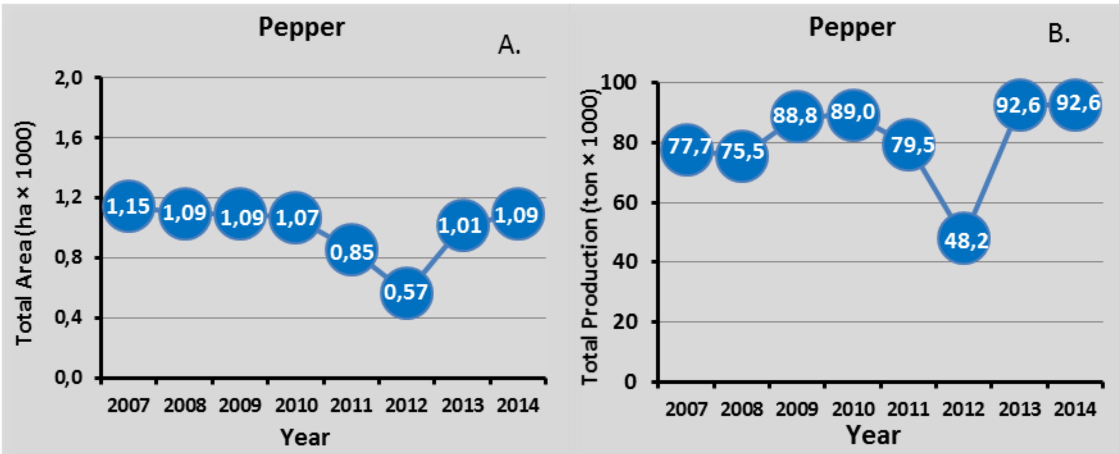


Figure 56 (A-B). Total area (A) and total production (B) of greenhouse pepper cultivated in Greek greenhouses during the years 2007-2014.

To improve the yield performance of pepper crops in the Greek greenhouse, extension of the cultivation period, and improved climate control with emphasis on maintenance of proper temperature levels are recommended. As already reported pepper is a warm season plant with an optimum temperature for production that ranges between

22-28 °C during the day and 16-18 ºC during the night. Thus, to successfully grow pepper in greenhouse and get satisfactory yields, a minimum temperature of 14 °C is needed during the day in the winter. On the other hand, a temperature difference of at least 4 °C but preferably 6 °C or higher between day and night is needed for optimal fruit setting. Thus, the night temperature should be adjusted to levels depending on the anticipated mean day temperature, so as to maintain the above-mentioned temperature difference between day and night, and at any case at higher levels than 14 °C.

The geographical distribution of the total greenhouse area cultivated with eggplant to the 13 Regions of Greece and the corresponding production in each region are shown indicatively for 2014 in Table 26. As shown in Table 26, Crete is leading in greenhouse pepper production with almost more than two-thirds of the total greenhouse area cultivated with peppers (67.4%) followed by Central Macedonia (22.4%) and Peloponnese (6.23%). The mild climate of Crete and southern Peloponnese which allows production of peppers in unheated greenhouses is the predominant reason for the leading position of these regions in pepper, because the fruit develop parthenocarpically and thus fruit set is not depending on high temperatures for sufficient pollen production and germination. Also Central Macedonia has the advantage of being close to the large consumption center of Thessaloniki. The mean yearly wholesale prices of greenhouseproduced pepper in the years from 2007 to 2013 are shown in Figure 57.

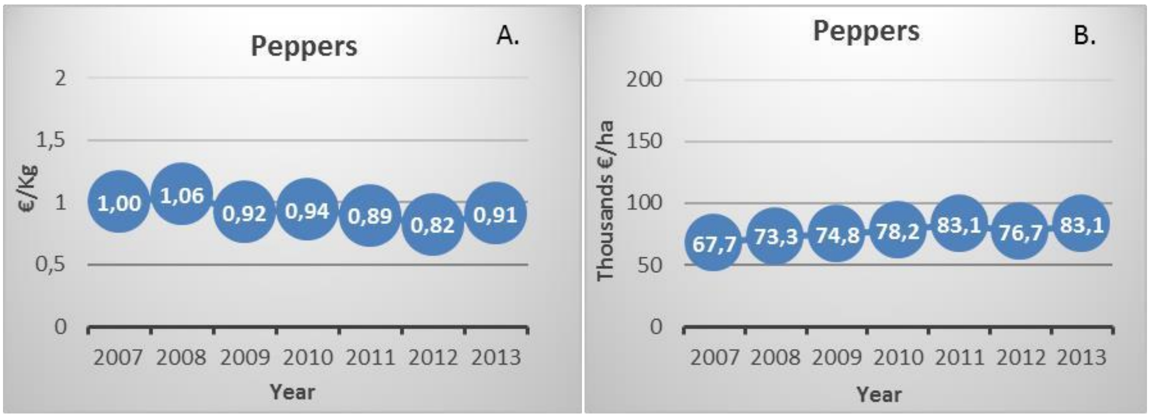


Figure 57 (A-B). Yearly average of the sales price for pepper and average gross revenues, during the years 2007 - 2013 (data from the Greek Ministry of Rural Development and Food).

1.2.7. Greenhouse watermelon

The cultivation of watermelon in tall greenhouses accounts for only a small part of the total watermelon production. Unfortunately, the Greek Ministry of Rural Development and Food (MRDF) does not distinguish between cultivation in low tunnels, high tunnels, and greenhouses, and thus, all watermelon crops in low tunnels are registered as "protected cultivation". According to the currently available data of MRDF, the "protected cultivation" of watermelon occupies 2,798 ha, which corresponds to 21,5% of the total area cultivated with watermelon in Greece. Nevertheless, only a small part of this area corresponds to high tunnels or other types of greenhouses. Indeed, according to older data (Savvas, 2007), only 28 ha of tall greenhouses were cultivated with watermelon in 2005.

Cultivation in high tunnels or greenhouses is aimed at producing early watermelon in April and May, which is recouped with high selling prices. However, watermelon is a warm-season vegetable with relatively high requirements in warm temperatures. Watermelon needs temperatures higher than 21 °C for at least four months to set and develop high-quality fruit. Thus, given the limited harvesting time and the high cost of heating, cultivation of watermelon in greenhouses for the domestic market is meaningful only in areas with mild winter, where the cost for heating is low. Watermelon production in greenhouses during the winter for the domestic market is restricted by the low domestic watermelon consumption at that time of the year. Winter production of watermelon in greenhouse for the export might be more meaningful but a market analysis on this is missing.

Table 27. Cultivated area and production of watermelons in low tunnels, high tunnels, and greenhouses allocated into the 13 regions of Greece in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area (ha)	(%)	Total production (ton)	Mean production (ton/ha)
Eastern Macedonia & Thrace	300	10,7	23	0,08
Central Macedonia	461	16,4	1.027	2,23
Western Macedonia	0	0,0	0	0,00
Epirus	23	0,8	1.279	0,00
Thessaly	209	7,4	10.589	50,68
Ionian Islands	15	0,5	0	0,00
Western Greece	984	35,0	19.500	19,81
Central Greece	2	0,1	0	0,00
Attica	0	0,0	0	0,00
Peloponnese	608	21,6	40.138	66,07
North Aegean Islands	164	5,8	15.880	96,99
South Aegean Islands	8	0,3	64	7,58

	41	1,5		
Total	2,815	100		
Crete			2.442	59,77
			90.942	32,31

As can be concluded by the geographical distribution of watermelon cultivation in low tunnels, high tunnels, and greenhouses, which is shown indicatively for 2014 in Table 27, the leading region in field watermelon cultivation is Westrern Greece with 35.0%, of the total area, followed by Peloponnese with 21.6%. Other important centers of watermelon cultivation in low tunnels, high tunnels, and greenhouses are Central Macedonia with 16.4% and Eastern Macedonia and Thrace with 10.7%.

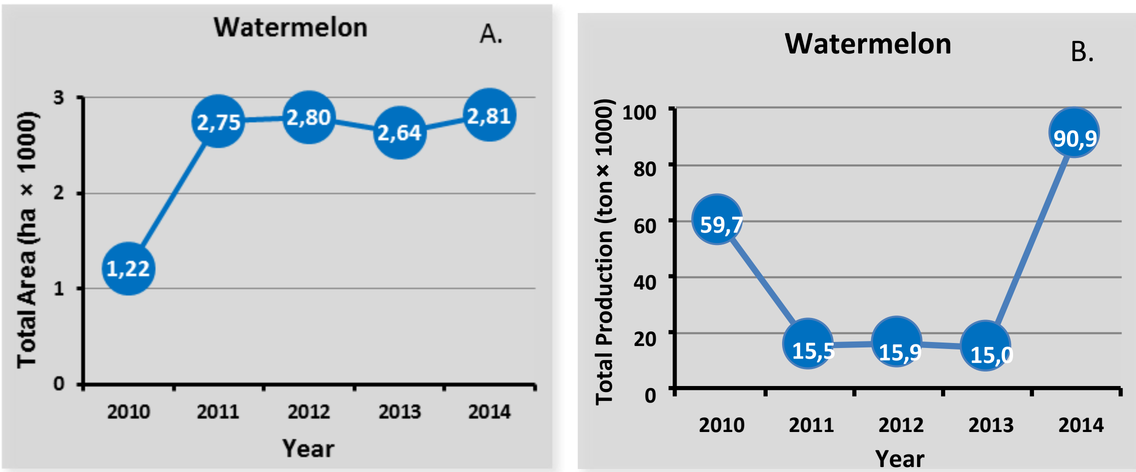


Figure 58 (A-B). Total area and total production of watermelon cultivated in greenhouses and low tunnels in Greece during the years 2010-2014.

1.2.8. Greenhouse zucchini

Zucchini has normally a short period of cropping and is, therefore, in many cases cultivated as a second crop in greenhouses. The common practice in Greece is to grow zucchini for about 3-4 and sometimes up to 5 months. The shorter cropping period is applied when zucchini is cultivated following another greenhouse plant considered as main crop (e.g. tomato, pepper, cucumber).

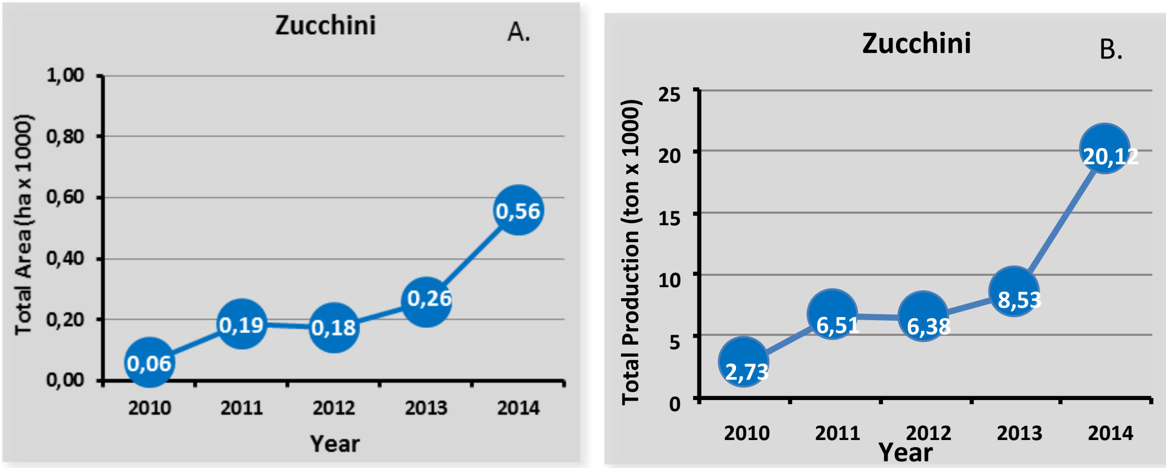


Figure 59 (A-B). Total area (A) and total production (B) of zucchini cultivated in greenhouses and low tunnels in Greece during the years 2010-2014.

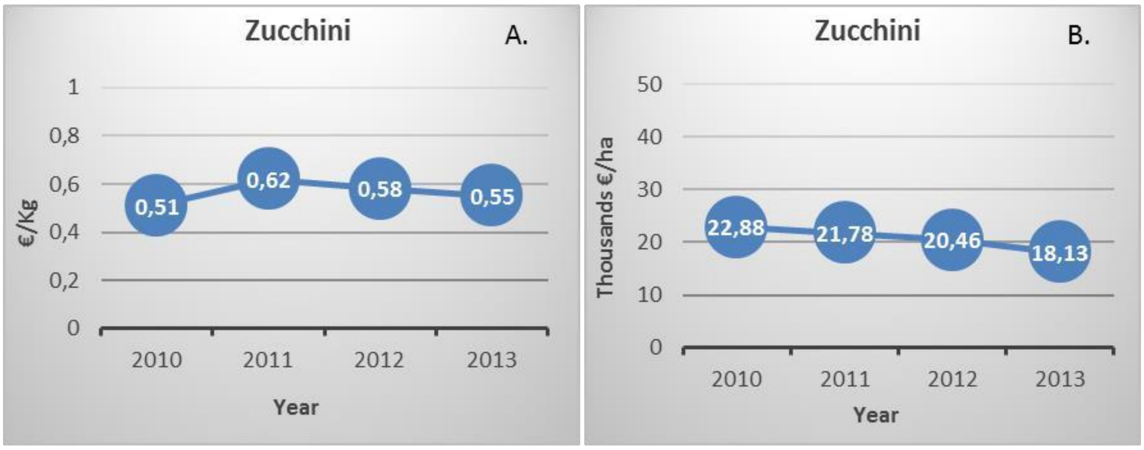


Figure 60 (A-B). Yearly average of the sales price for zucchini and average gross revenues, during the years 2010 - 2013 (data from the Greek Ministry of Rural Development and Food).

According to the statistics of the Greek Ministry of Rural Development and Food (MRDF), the protected cultivation of zucchini ranged between 249 and 286 ha during 2008-2013 but rose to 567 ha in 2014 (Figure 59). This area includes both greenhouses and low tunnels. Unfortunately, in the last years the MRDF does not keep separate statistical data for low tunnels and tall greenhouses. According to older data originating from the MRDF (Savvas, 2007), about 60% of the total protected area with zucchini takes place in tall greenhouses (mainly high tunnels), while the remainder corresponds to low tunnels. According to these data, about 15-20% of the total protected cultivation of zucchini corresponds to greenhouses in which zucchini is grown as a second crop during the same year. With respect to the regional distribution, Western Greece with 350 ha in 2014 accounted for over 60% of the total area cultivated with zucchini under cover in Greece, followed by Central Macedonia with 12.5% and Peloponnese with 10.2% (Table 28). More than half of the protected cultivation of zucchini originates from high and low tunnels located in the prefecture of Ilia, which provides favorable conditions for early production.

Table 28. Cultivated area and production of zucchini in Greek greenhouses allocated into the 13 regions of the country in 2014 (data from the Greek Ministry of Rural Development and Food).

Region	Total area (ha)	(%)	Total production (ton)	Mean production (ton/ha)
Eastern Macedonia & Thrace	1	0.2	34	37.56
Central Macedonia	71	12.5	942	13.31
Western Macedonia	0	0.1	12	36.36
Epirus	12	2.2	449	36.23
Thessaly	3	0.5	63	24.45
Ionian Islands	1	0.2	1	0.79
Western Greece	350	61.7	15,540	44.40
Central Greece	10	1.8	210	20.08
Attica	16	2.8	60	3.78
Peloponnese	58	10.2	1,223	21.14
North Aegean Islands	7	1.2	220	31.43
South Aegean Islands	10	1.7	56	5.70
Crete	28	4.9	1,309	47.53
Total	567	100	20,120	35.49

As shown in Table 28, the total yearly zucchini production obtained from protected cultivation during 2007-2014 fluctuated from 7,974 ton in 2012 to 20,120 ton in 2014. These large differences in total zucchini production under cover from year to year are partly due to commensurate differences in the total cultivated area. However, the fluctuation in total production indicates also differences in the average yield performance from year to year, which ranged from 31.09 tons ha^{-1} in 2012 to 71 tons ha^{1} in 2009 with an average of 45 tons ha^{-1} over these 7 years. This yield level, although estimated by taking into consideration also the low tunnels, is considered unsatisfactorily. On the other hand, one should take into consideration that this yield is obtained by utilizing the greenhouse for half a season, while during the second half of the year an additional crop is commonly grown. Thus, the net income estimated on the basis of the above-referenced yield represents roughly half of the total greenhouse income.

In figures 60 and 61, the mean yearly wholesale prices of zucchini from 2010 to 2013 and the fluctuation of the monthly wholesale prices in 2013 and 2014 are graphically shown. The data presented in these figures clearly show that the highest sales prices of zucchini are achieved during the cold-season months, particularly from December to February or March, while in May and June the sales prices decrease to the mean yearly level. These data show that the production of zucchini in greenhouses during the winter provides the highest gross revenues. However, zucchini is a warm season vegetable and thus, to obtain a satisfactory yield in winter, heating may be necessary in most locations. Although zucchini is more tolerant to sub-optimal temperatures than cucumber, higher temperatures than 18 °C during the day are needed for sufficient pollination. Nevertheless, many cultivars of zucchini may set parthenocarpic fruit. Thus, in out of season zucchini crops, in which pollination may be inadequate because staminate flowers or pollinating insects are absent, the use of cultivars with an inherent ability to set parthenocarpic fruit may enhance fruit set and thus total yield.

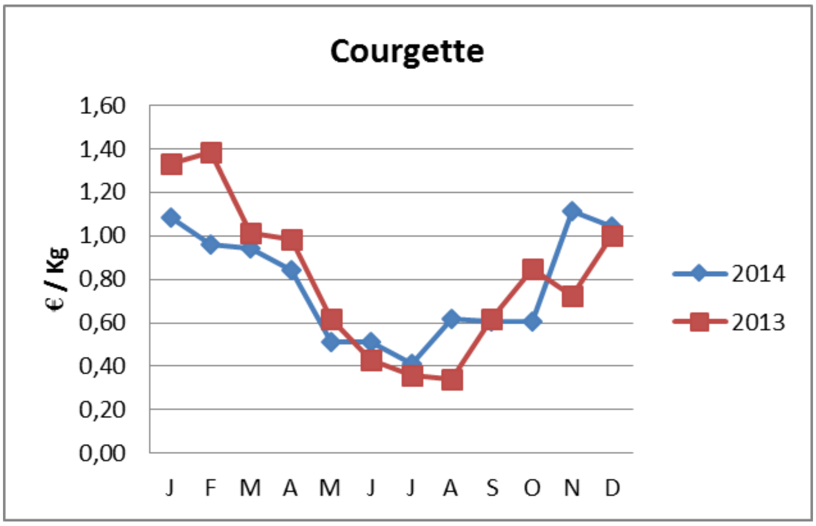


Figure 61. Mean monthly prices for fresh-market zucchini during the years 2013 and 2014 at the Thessaloniki Central Fresh Fruit and Vegetable Wholesale Market.

If a yield of 60 tons ha^{-1} is obtained in a winter crop of zucchini in greenhouse, and an average sales price of 1.1 € kg^{-1} is achieved, a gross revenue of 66,000 € ha^{-1} is estimated. The plant density of zucchini in greenhouses ranges from 1 to 1.5 plants m^{-2}.

With a price of 0.23 € per seedling, a cost of about 3,000 € ha^{-1} is needed for propagation material. In comparison with an unheated tomato crop, a zucchini crop incurs lower costs also for fertilization, labor, package, and consumables (e.g. no need for plant support) but the other costs are similar, while zucchini (depending on the site location) may need also some heating. Thus, a total cost of about 50,000 € ha^{-1} may be needed in an unheated greenhouse for zucchini production. This cost level leaves a limited profit margin to growers, taking into consideration a gross revenue of 66,000 € ha^{-1}, as previously referenced. If some heating is applied, the cost may rise up to about 80,000 € ha^{-1}. On the other hand, in a heated greenhouse, the yield may be even doubled. If the greenhouse is heated and protected by insect screens and other measures preventing insect entry and pathogen spread, the cropping period can be extended, and this can further increase the total yield. Under these conditions, winder production of zucchini may provide a reasonable profit to growers. Actually, the key factor for achieving a reasonably high profit in a greenhouse crop of zucchini is the yield level, which has to be maximized by selecting high-yielding cultivars suitable for winter production, efficient plant protection and fertilization practices, and extending the cropping period to maximize resource utilization. The production cost should also be maintained to a reasonable level but there are lees possibilities to maximize the profit by further reducing costs than by maximizing yield.

1.2.9 Greenhouse lettuce

Lettuce is the only cool-season vegetable which is also grown under cover, particularly during winter. Lettuce protected cultivation in Greece is rather serious, in terms of production rather than areas (Fig. 62). It has to be mentioned that about 1015% of lettuce total production in Greece comes from protected cultivation. Under cover lettuce culture is done mostly in simple, low-cost, non-heated structures without proper climate control just as to provide protection to plants under harsh conditions in the field (e.g. frost, heavy rains, strong winds etc.). Even in this case, protected cultivation increases yields, improves quality of produce and reduces crop duration from transplanting to harvest, thus increasing crop cycles per year. For instance, under cover, crop duration from transplanting to harvest may last from only 1 month under favorable conditions up to 2 months during winter in low-cost structures with poor climate control. As a result, more than 6 crops per year could be done in low-cost greenhouses, whereas in high-tech greenhouses using soilless culture, more than 7-8 successive crops per year can be attained. Lettuce is an ideal crop for production in virtually all systems of soilless culture (e.g. NFT, inorganic substrates, floating systems, aeroponics); hence there is an increasing interest for soilless lettuce crops in modern, high-tech greenhouses, using ultra dense planting and proper climate control.

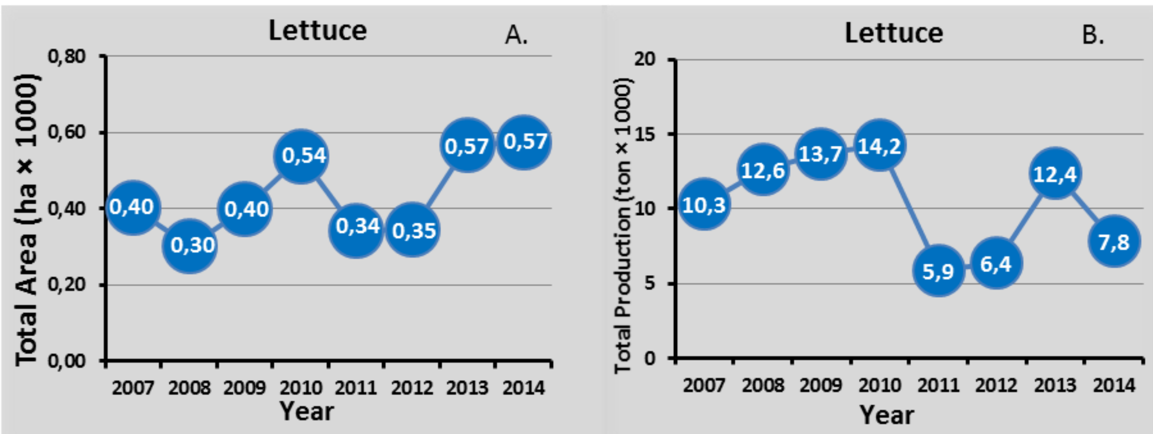


Figure 62 (A-B). Total area (A) and total production (B) of lettuce cultivated in greenhouses and low tunnels in Greece during the years 2010-2014.

In greenhouses, lettuce is commonly planted more densely, at 18x18 cm or 20x15 cm in heading types (e.g. iceberg) with small size, resulting in 330,000 plants per ha, without limiting the size of the plants at harvest. Dense planting together with the increase in crop cycles, result to far more plants per ha and per year in greenhouses than in the field, thus increasing yields substantially, up to 90 tons/ha or more in the case of intensive soilless culture. In addition, the more or less controlled conditions under protected cultivation lead to reduced losses of plants because of diseases and pests.

Therefore, despite the initial investment for the installation of a greenhouse, under cover lettuce production is far more profitable than a field crop, due to increased yields, both as total weight and number of plants per area unit and in particular as protected cultivation ensures production under non-favorable conditions in the field. This should be seriously taken into consideration by growers, as the last few years due to climate change more frequent episodes of extreme climatic conditions are encountered, resulting in heavy crop losses. Although there are no data on farmers revenues per ha of greenhouse lettuce, those are expected to be much higher than the respective values of field cultivation.

However, as lettuce plants do not grow well under high temperature conditions, greenhouse lettuce production in Greece cannot last all year, as the respective crops in northern countries do. For instance, during late spring and summer plants grown under cover usually show symptoms of "tipburn" (marginal necrosis of leaves caused by limited Ca supply), in particular when grown on floating hydroponics.

As greenhouse production coincides with field production, there is no serious difference in prices between under cover and field lettuce. However, greenhouse lettuce, especially those grown in hydroponic systems, have better appearance, are free from dirt and soil; thus are consumed in total contrasting to field lettuce in which much of the outer leaves are discarded, and are therefore more attractive to consumers, who are willing to pay more for those products.

Appendix I

BUSINESS PLAN 1.

Background information
1. Business name: Hydro-Tomato
2. Location: Municipality of Trifylia, Peloponnesus

3. Economic Sector: Fruits and Vegetables.

4. Farming operations: Hydroponic greenhouse tomatoes production

5. Establishment Year: 2016.

6. Type of ownership: family-owned agricultural business

Executive Summary

The company and the product

Hydro-Tomato is a family-owned agricultural business that utilizes a 0.8 ha modern hydroponic greenhouse to produce high quality hybrid tomatoes for the domestic market. From the second year of operation, Hydro-Tomato targets on a total of 320 tons of produce. The quality of the produce can insure a price premium of about 20% for the 90% of total production.

The Hydro-Tomato utilizes family labor in the production process. However, to meet the labor needs of the hydroponic greenhouse production the farm will hire two permanent workers. Also, seasonal workers will be hired to cover specific labor intensive farm operations.

Competitive advantages

There three main competitive advantages of the Hydro-Tomato company are:

1. High-quality of the produce, that ensures a premium price for 90% of the produce.
2. Increased productivity, due to the modern technology production
3. Strategic location, that ensures low shipping costs and easy access to the central market of Athens

The Market

The off-season vegetable production is well-established in Greece. Domestic market is traditionally large, as the consumption of tomatoes per person is very high in the country. Nevertheless, the increased foreign competition as well as the current economic crisis may affect the market in favour of seasonal vegetables, or cheap imported tomatoes. Additionally, many newcomers have appeared in the production of off-season vegetables, and especially tomatoes, in other areas in Greece (mainly in Northern Greece). Therefore, the geography of tomato cultivation has been altered and in the near future, significant changes are expected, with an important market share moving from the southern part of Greece to the Northern. Moreover, the typical structure of the greenhouses has been changed. More capital intensive investment that involve large and modern greenhouses appear, and this trend is expected to persist in the near future.

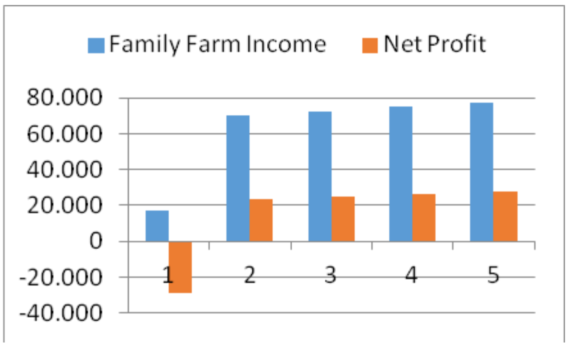
In this competitive environment, the high quality of the production and the increased productivity are the main factors that can reassure a positive outcome from the investment. Moving across this line, Hydro-Tomato can gain a significant market share. During the first five years of operation, the farm will collaborate with wholesalers of the central market of Athens, but after this period, the farm will reconsider its options.

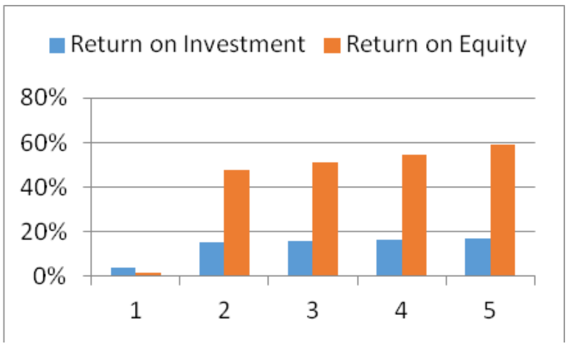
Financial plan

The company is seeking to raise investment for the purpose of financing the acquisition of the land, the construction of the greenhouse, the purchase of the necessary equipment, and its cash-flow needs. To finance the start-up expenses, the business will receive a state support that will cover the 50% of the total cost of the investment. Moreover, another 25% of the cost of the investment is covered by a 5 years bank loan and the remaining start-up expenses are owner-financed. Finally, each year, the company receives a short-term loan to ensure its cash-flow, especially during the preharvest period (from August till November).

Economic Results

The following figures depict the main economic results for the farm business (net profit and family farm income). The net profits are positive (apart from the first year of operation) and the level of the family farm income supports the prosperity of the project. Moreover, the Return in investment ratios suggest that the business produces positive outcomes. Finally, the Net Present Value of the investment is very high, thus revealing the attractiveness of the investment (152,770 €).





1. Company Summary

Hydro-Tomato is a family farm business that produces high quality tomatoes for the domestic market. It targets towards increased productive efficiency by utilizing hydroponic systems and recent technologies (heating and cooling system, etc.). the produce can be sold at higher prices than the majority of off-season produced Greek tomatoes.

Mission

The production of high-quality, heathy and tasteful tomatoes mainly for the domestic market.

Objectives

The establishment of an intensive high-technology, hydroponic greenhouse farm, with increased productivity and optimum production quality. The company targets the distribution to wholesalers of the Central Market of Athens, from November till June.

2. Company targets

The main target of the company is to produce high-standards tomatoes for the domestic market. Specifically, the company targets on a total of 320 tons of production from a 0.8 ha hydroponic-system greenhouse. This is a realistic target although the average tomato yield per hectare of Greek greenhouses is less than 200 tons. The high-technology equipment, the carefully designed production process that minimizes losses in both production and input and available experts' advice ensure the achievement of this target. The company will reach the expected production level during the second year of operation. The production level of the first year is assumed 10% lower.

The second target is related to the quality of the production. Specifically, about 90% of the produce (256 tons) are expected to be of extra quality. As the quality of the production is the optimum, the business expects to sell its production at high prices throughout the year (average of 1.02 €/kg for the extra quality and 0.68 €/kg for the lower quality tomatoes). However, during the first year of operation, an average price of
0.91 for the extra quality and 0.61 for the lower quality produce are expected, as the company's market share will not be well established yet.

After the fifth year of operation, the managers will reconsider the expansion of the facilities to cover the potentially excessive market share. The decision to expand its clientele will be based on their total sales but also in the potential producer price increase.

3. Start-up Finance

The business is seeking to raise investment for the purpose of financing the acquisition of the land, the construction of the greenhouse, the purchase of the equipment, and the operating cash. The start-up period lasts three months, and includes the construction process as well as the acquisition of the equipment and the preinvestment studies.

The start-up financial plan (Table 1) includes state support for the 50% of the investment. Specifically, the investment can be financed through the “Measure 4” of the “Greek Rural Development Program” for the 2014-2020 programming period, or the National Investment Law. Another 25% of the investment will be covered by a 5-year bank loan, with a 8.25% interest rate. Additionally, the remains 25% of the investment will be covered by own capital.

Finally, the company will receive a yearly short-term loan to ensure its cash-flow, especially for the pre-harvest period (from August till November). This loan corresponds to 50% of the variable costs, with an interest rate of 8.25%.

Table 1. Financial plan

	Year 0	*Year 1º*	*Year 2º*	*Year 3º*	*Year 4º*	*Year 5º*
Own capital	123,188					
%	25					
Bank loans	123,188	74,026	77,664	77,664	77,664	77,664
%	25					
Subsidies	246,375					
%	50					
TOTAL	492,751	74,026	77,664	77,664	77,664	77,664
%	100	0	0	0	0	0

4. Key to success

There three main competitive advantages of the Hydro-Tomato company are:

1. High-quality of the produce. The hydroponic cultivation uses modern hightechnology production systems which allow the production of a very distinct and highquality product that can easily gain a share in the market.

2. Increased productivity. The hydroponic-cultivation and the modern equipment of the greenhouse, ensure optimum climate conditions, adequate nutrients intake and plant health, and as a result, maximise yields.

3. Strategic Place. The area of Trifylia is located in a very strategic region, close to the central market of Athens. Shipping costs are also low and the produce can easily reach other markets in the future through Athens and Patra's harbour.

5. Market Analysis

5.1 Market segmentation

In the beginning of the operation, Hydro-Tomato will target the Greek domestic market, and all production will be forwarded to the wholesalers of the central market of Athens. In order to achieve this target, the manager intents to invest in the promotion of the produce through personal communication with selected wholesalers. After the company sets well in the market, the manager will seek for new collaborations and may also invest in direct sales.

5.2 Location of the farm

The location of the farm is in a very strategic point in Greece, close to the central market of Athens and to the Patra's harbor. Due to the recently developed road network, the economic geography of this area has been changed dramatically and new opportunities for investments, especially in the primary sector have risen. Moreover, the area is characterized by a favorable climate, suitable for the production of off-season vegetables.

5.3 Competition

The Hydro-Tomato company has to operate in a high competitive environment. Off-season tomato production is a well-established agricultural activity in several areas in Greece and abroad. There are plenty of greenhouse farms that distribute tomatoes to the central market of Athens, located in different areas in Greece. In general, there are about 5,500 hectares of greenhouses in Greece, 3,500 of which produce tomatoes with a total production of 300,000 tons.

The main productive areas are Crete and Peloponnesus. However, there is a recent trend for the production of off-season vegetables, and especially tomatoes, in other areas in Greece. Therefore, the geography of the cultivation is altered and in the near future, significant changes are expected, since the northern part of Greece will gain an important market share. Moreover, the structure of the greenhouses has diversified. Current investments

involve large and modern greenhouses. This trend is expected to persist in the future.

Additionally, there is an increased international competition, that strongly affects not only the international but the domestic market. Imports from "traditional" tomato producing countries (like Belgium, Spain, Italy) but also from newcomers in tomato production (like Poland, Skopia, Albania, Bulgaria and Morocco) negatively affect the expansion of the market share of the Greek produced tomatoes. However, it is important to mention that from 2010 to 2014, tomato exports increased by about 550%, while the imports reduced by about 40%.

Despite the environment of intense competition, the demand for high-quality offseason tomatoes is very high. Moreover, the market of hydroponic tomatoes in Greece is distinct and still expanding. It is estimated that there are about 75 hectares of hydroponic greenhouses producing tomatoes. About 1/3 of these are located in the Peloponnesus area.

5.4 Market structure

The domestic market is large, as the consumption of tomatoes per person is very high in Greece. However, as already mentioned, very intense changes in the market are taking place during the last few years. Several well-funded projects of hydroponic vegetable cultivation are implemented in Greece, that take advantage of economies of scale, use high-tech production systems and utilize low-cost energy (like geothermal energy). Moreover, new family businesses invest in small or medium-sized greenhouses all over Greece. Therefore, there are many domestic competitors in the market. In addition, domestic growers face an increased pressure caused by the imports of tomatoes from several countries. In this competitive environment, the high quality of the production, and the increased productivity of Hydro-Tomato company are key factors for success.

Suppliers Power: In the area of Trifylia, there are plenty of farm supply stores, where the owner can purchase the necessary inputs for the hydroponic greenhouse production. This competition can work in favour of the company, since it can achieve low prices for its inputs.

Buyer Power: A structural problem of the primary sector in Greece is the relatively high power of the wholesalers, that can negatively affect producer prices. However, the increased volumes and the quality of the production of the Hydro-Tomato grant the company with bargaining power and help it achieve a favourable price for its produce.

5.5 SWOT ANALYSIS

Strengths	Weaknesses
The strengths stem mainly from the fact that the company uses greenhouse hydroponic production systems. Therefore: • Poor quality and less expensive farmland can be utilized • Optimal nutrients intake and pH levels can be achieved • Higher yield, relative to conventional soil production systems can be achieved • The use of herbicides is unnecessary • Good farming practices can easily be adopted and certified production requirements can be met. • The production is not subject to unfavorable weather conditions. • Irrigation water usage is optimal • Higher producer prices relative to conventional tomatoes can be achieved, especially since products will be certified as Integrated Management Systems products Furthermore, the company works in collaboration with an expert in the field, who can identify and efficiently cope with emerging production	• Hydroponic greenhouse Therefore, the start-up c can be substantially hig • Errors can be made unti with the hydroponic pro company needs expert a reassure high yields and • The production system r monitoring
problems and support high quality and quantity of production. Finally, the strategic location of the company contributes to the low shipping cost of the produce. The location of the company also facilitates input supply, since Trifylia is a traditional agricultural area with plenty of farm supply stores.	

Opportunities	Threats
• The Greek hydroponic production industry is adequately supplied with greenhouse technology and farm inputs • The tomato market is large and the demand for high quality hydroponic products is rising, despite the financial crisis • Current reforms in the institutional environment promote low water and chemical use systems like hydroponics • The national and EU agricultural policies support this type of agricultural investment (e.g. National Development Law and programs included in Measure 6 of the new Greek Rural Development Program 2014-2020). • The hydroponic system supports organic production. In the future the company may consider the adoption of organic production.	• Not all consumers are fa hydroponic production. unnatural production sy amounts of chemical pro • The company is vulneral • The market is highly con • The company receives h other growers that utiliz

6. Products and production process

6.1 Product description

Hydro-Tomato produces high-quality hybrid tomatoes, of medium size (about 250 gr) following the Integrated Crop Management standards. According to the estimated yield, the farm can produce about 320 tons of tomatoes after the second year of operation (Table 2). It is estimated that 10 % of the produce will be classified as quality B. Quality B tomatoes do not have the desired characteristics regarding their size, shape and color.

Table 2. Tomatoes production per year (tons)

Year	*1*	*2*	*3*	*4*	*5*
quality A	230,4	256	256	256	256
quality B	57,6	64	64	64	64

6.2. Description of the production process and the equipment needed

The Hydro-Tomato company produces tomatoes using a modern and well-developed greenhouse and a hydroponic system. The greenhouse is metallic, tunnel-type with plastic cover. Hydroponics is a technology for growing plants in nutrient solutions with or without the use of an artificial medium to provide mechanical support. The hydroponic systems are categorized as open (i.e. nutrient solution is delivered to plant roots, and then it is discarded) or closed (i.e. the surplus solution is recycled).

Hydro-Tomato uses a closed hydroponic system with pumice as a substrate. Temperature is measured and controlled using heating and cooling systems and climatic control system.
Hydro-Tomato uses drip-irrigation and a fertigation system for nutrients intake.

The main equipment needed for the production process are:

- Electrical installations
- Generators (electric)
- Water tanks, pumps and irrigation system
- Fertigation system, that provides nutrients as well pests and diseases control inputs through the irrigation system
- Heating system (indoor system and outdoor unit)
- Cooling system
- Climate control system
- Heat curtain
- Hydroponic channels
- Drainage system
- UV purification system
- Cold room

The Hydro-Tomato company has already received a price quote from a local supplier to purchase the above equipment. The cost of equipment is described in Table 6 (Section 8.1). The necessary inputs for the production process (like nursery plants, fertilizers, pesticides etc.) are supplied by local suppliers. Details on the hydroponic systems and the production process can be found in Section 3 of Study 5: Vegetables: Open-Field and Greenhouse Production.

6.3 Personnel

The Hydro-Tomatoes is a family business that utilizes family labor for the production process. However, the company has to hire permanent workers to cover the needs of the greenhouse throughout the year. To meet labor demands, the company will hire two permanent workers, who will be asked to attend a special seminar on technical details and management of hydroponic cultivation and equipment. Additionally, to cover seasonal needs, daily-working labor will be hired. It is estimated that 250 daily wages will be necessary. Finally, the owner is responsible for the management of the company. The personnel costs are presented in Table 3.

Table 3. Personnel of the company

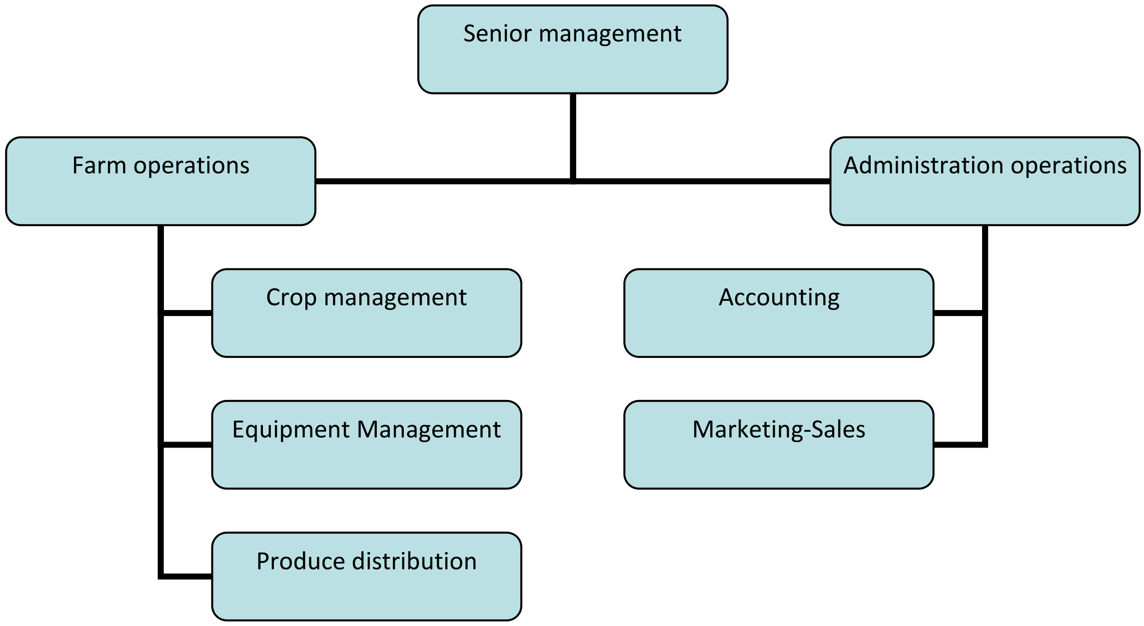
	Number	Yearly Cost (€)
Specialized Labor	2	30,000
Non-specialized labor (seasonal)	5	8,750
Manager – Owner	1	16,000
TOTAL	**8**	**54,750**

6.4 Organizational plan

The senior management is carried out by the owner of the company, who is also responsible for the production process and the marketing and sales strategy of the company. The two permanent workers are assisting farm operations. Seasonal workers are needed for specific labor intensive farm operations, like pruning and harvesting.

Finally, the company collaborates with an external accounting service provider as well as with an agriculturalist that pays weekly visits to the greenhouse and overseas crop management together with the owner. Finally, the distribution of the produce is subcontracted to a local shipping company.

Figure 1. Organizational plan



7. Marketing strategy according to the marketing mix

7.1 Sales strategy

The company expects to receive the maximum price level for the tomato produce, given its high-quality. According to Table 4, the average price per month for tomatoes in the central market of Athens highly fluctuates. However, it is expected that due to the quality of the produce, the Hydro-Tomato can gain a significant price premium of about 20%. Therefore, the average producer price is expected to be on average 1.02 €/kg for the extra quality produce. For the lower quality produce, the average price is expected to be much lower (0.68 €/kg).

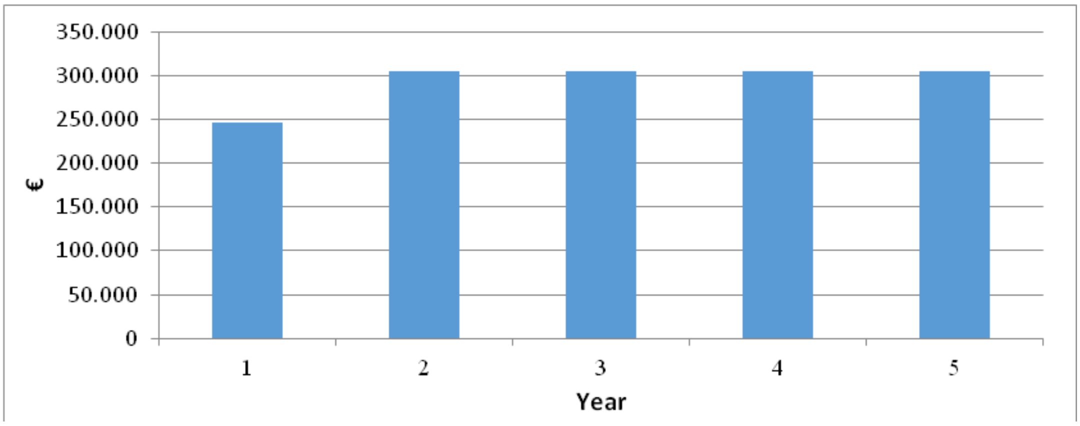
The market research reveals that there is a demand for high quality tomatoes, and therefore, these prices are expected to be reached during the second year of operation. During the first year, the average price is expected to be about 10% lower, due to the incomplete marketing.

Table 5. Hydro-Tomato monthly producer price estimation.

	J	F	M	A	M	J	J	A	S	O	N	D	Mean
Producer prices in the central market of Athens													
2014	0.84	0.71	0.93	0.94	0.70	0.70			0.80	0.83	0.86	0.88	0.82
2013	1.04	0.89	1.06	1.14	1.06	0.74			0.70	0.64	0.54	0.96	0.88
Average	0.94	0.80	0.99	1.04	0.88	0.72			0.75	0.74	0.70	0.92	0.85
Hydro-Tomato average producer prices (20% higher for quality A and 20% lower for quality B)													
Quality A	1.13	0.96	1.19	1.25	1.05	0.86			0.89	0.88	0.84	1.10	**1.02**
Quality B	0.75	0.64	0.80	0.83	0.70	0.58			0.60	0.59	0.56	0.73	0.68

Given the producer prices and the expected production (see Table 2), the sales forecast is presented in Figure 2.

Figure 2. Sales forecast



7.2 Distribution strategy

The produce will reach the central market of Athens, via an external partnership with a shipping company. Given the distance from Athens and quality of roads, the transportation costs are expected to be about 0.05 €/kg of tomato.

7.3 Marketing Strategy

The marketing strategy of the company includes the development of its corporate identity and specifically:

- the design of its logo,
- the development of its website,
- personal communications with selected wholesalers in the central market of Athens,
- registration of the company in professional yellow pages and
- advertising in newspapers and other agricultural related magazines.

The logo will be printed on the company's crates, stationery and invoices so that the clientele can easily identify the company. The website and the registration in the professional yellow pages enables potential customers to communicate with the company. Finally, advertising and personal communication with selected wholesalers is necessary so that the company can approach its clientele.

The company will undertake this promotion cost during the first year of its operation. This cost is estimated at 10,000. After the first year of operation, promotion will be cut down to 2,000 €.

8. Financial Plan

8.1. Start-up investments

Table 6 presents the start-up budget for the investment, which is estimated at 483.377 €. The main part of the budget regards the construction of the greenhouse and the necessary equipment for the production process (Figure 3).

Figure 3. Start-up investment budget breakdown

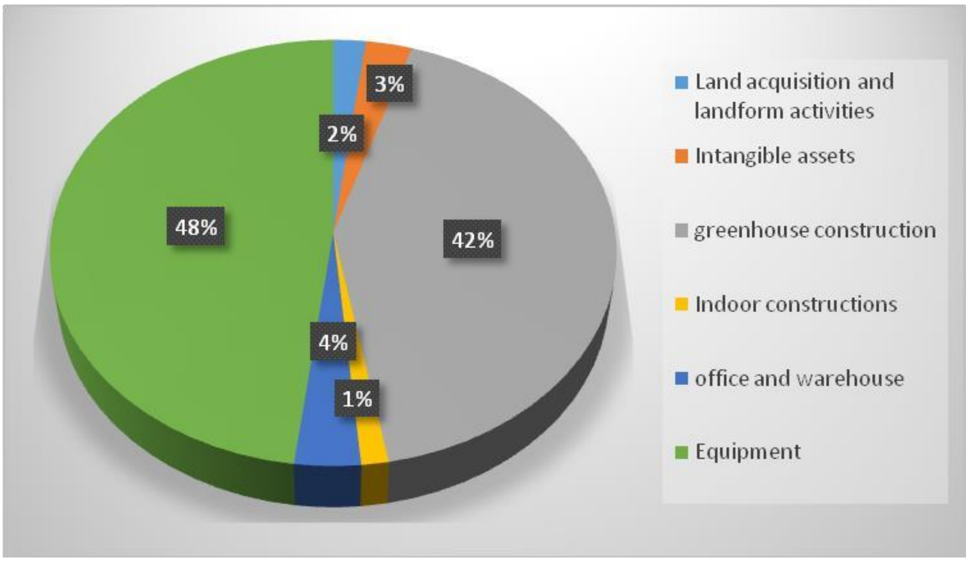


Table 6. Start-up investment budget

Investment	*Value (€)*
Land acquisition and landform activities	10,000
Pre-investment studies and other expenses for licensing	4,250
Promotion	10,000
Metallic Tunnel-type greenhouse with plastic cover	208,080
Indoor constructions	6,970
400 square meters office and warehouse	17,000
Equipment	237,077

Electrical installations	*3,570*
Electric generator	*7,395*
Irrigation system and pumps	*6,800*
Fertigation system	*11,220*
Heating system (indoor system and outdoor unit)	*44,710*
Cooling system	*40,800*
Climate control system	*8,160*
Heat curtain	*54,400*
Hydroponic channels	*6,120*
Hydroponic substrate (pumice)	*4,930*
Drainage system	*5,525*
UV purification system	*11,730*
Cold room	*20,400*
Water tank (186 cubic meters)	*6,630*
Other expenses	*4,687*
TOTAL	483,377

8.2. Annual production costs

Table 7 presents the annual production costs for the first five years of operation. According to Figure 4, the main part of the annual costs (48%) regards the variable costs, while the non-variable costs and the labor costs represent 32% and 20% of the annual cost, respectively. Variable costs consist mainly of the energy costs (diesel and electricity), packaging and shipping costs, purchase of fertilizers and pesticides as well as the central market commission (Figure 5).

Figure 4. Annual cost breakdown

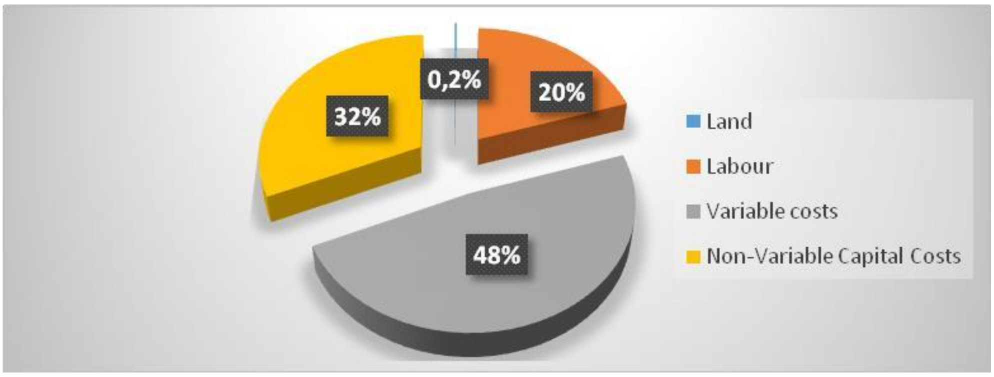


Figure 5. Annually variable costs breakdown.

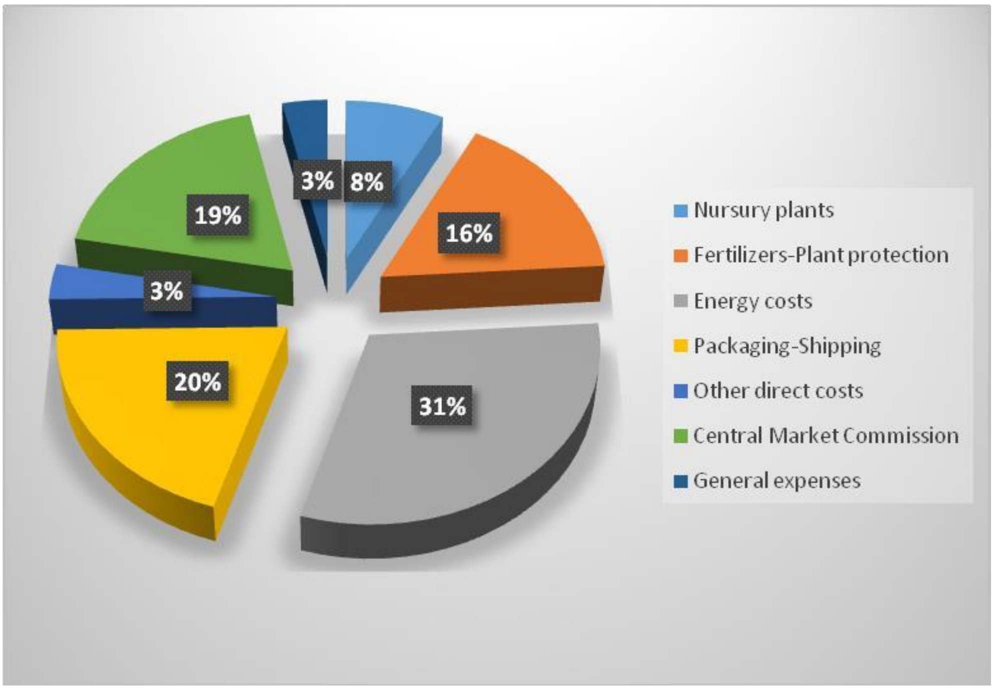


Table 7. Annual costs breakdown (in €).

Year	1	2	3	4	5
Land	560	560	560	560	560
Labour	54,750	54,750	54,750	54,750	54,750
Permanent	*46,000*	*46,000*	*46,000*	*46,000*	*46,000*
Seasonal	*8,750*	*8,750*	*8,750*	*8,750*	*8,750*
Capital Costs	220,359	226,094	224,552	223,010	221,468
Variable costs	133,436	140,424	140,424	140,424	140,424
Nursury plants	*10,080*	*10,080*	*10,080*	*10,080*	*10,080*

Fertilizers-Plant protection	*21,880*	*21,880*	*21,880*	*21,880*	*21,880*
Energy costs	*41,000*	*41,000*	*41,000*	*41,000*	*41,000*
Packaging-Shipping	*26,800*	*28,000*	*28,000*	*28,000*	*28,000*
Other direct costs	*4,400*	*4,400*	*4,400*	*4,400*	*4,400*
Central Market Commission	*24,676*	*30,464*	*30,464*	*30,464*	*30,464*
General expenses	*4,600*	*4,600*	*4,600*	*4,600*	*4,600*
Non-Variable Capital Costs	86,923	85,670	84,128	82,586	81,044
Depreciation	*26,772*	*26,772*	*26,772*	*26,772*	*26,772*
Insurance	*3,895*	*3,783*	*3,671*	*3,559*	*3,447*
Maintenance	*9,780*	*9,463*	*9,147*	*8,830*	*8,513*
Interests	*46,476*	*45,652*	*44,539*	*43,425*	*42,312*
TOTAL	275,669	281,404	279,862	278,320	276,778

Finally, Figure 6 depicts the annual costs per year of operation. Annual costs are slightly increasing after the first year of production, since the latter receives its maximum level. Additionally, the contribution of each cost item to the annual costs is almost stable.

Figure 6. Forecast of annual costs for the first five year of the investments.

8.3. Economic results

Table 8 presents the economic indices for the company. Apart from the first year of operation, the Hydro-Tomato presents positive Net Profits, and very high Family Farm Income (FFI), a significant index in agricultural economics (see also Figure 7). FFI indicates the compensation of the production factors that belong to the family plus the net profit; thus, it is a measure of family welfare. A positive and high level of FFI points out the economic sustainability of the family farm business. FFI is calculated as the sum of the net profit, the implicit rent of the farmland, the implicit cost of family labour and the opportunity cost of family-owned capital (interests).

Table 8. Forecast of economic indices

Year	*1*	*2*	*3*	*4*	*5*
Sales forecast	246,758	304,640	304,640	304,640	304,640
Variable costs	148,051	155,327	155,327	155,327	155,327
Non-variable costs	127,618	126,076	124,534	122,993	121,451
Explicit costs	199,236	203,808	201,625	199,289	196,786
Implicit costs	76,433	77,596	78,237	79,031	79,993
Total expenses	275,669	281,404	279,862	278,320	276,778
Gross Profit	98,707	149,313	149,313	149,313	149,313
Profit (excl. tax, depreciation, interests)	44,338	95,660	96,088	96,517	96,946
Family farm income	16,856	70,278	72,572	75,021	77,636

Net profit	-28,910	23,236	24,778	26,320	27,862
Profit Margin	-11.72%	7.63%	8.13%	8.64%	9.15%
Return on investment	3.78%	14.91%	15.45%	16.02%	16.63%
Return on equity	1.55%	47.47%	50.92%	54.72%	58.91%

Finally, the return on investment and the return on equity are also positive and reveal the attractiveness of the investment (see also Figure 8).

Figure 7. Net Profits and Family Farm Income of the operation (€)

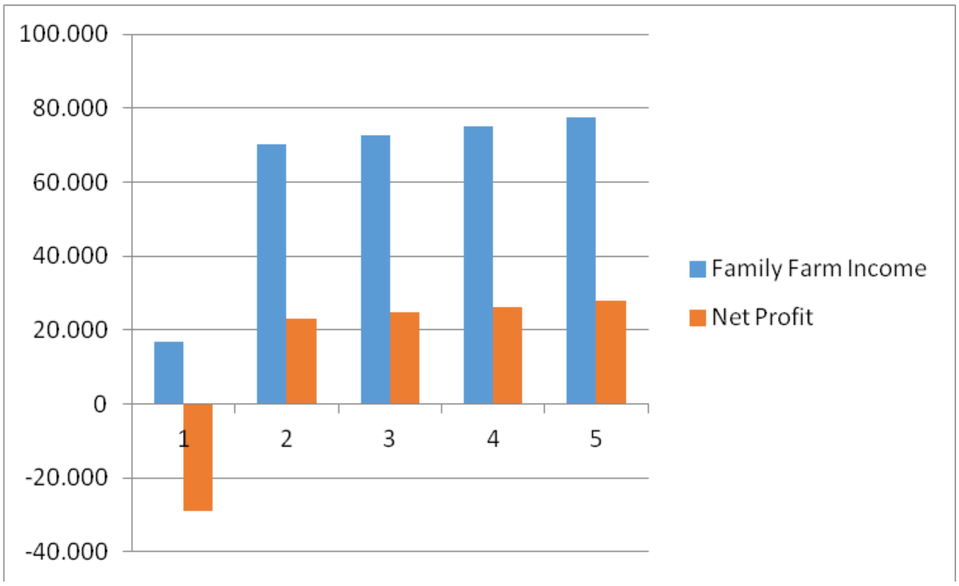
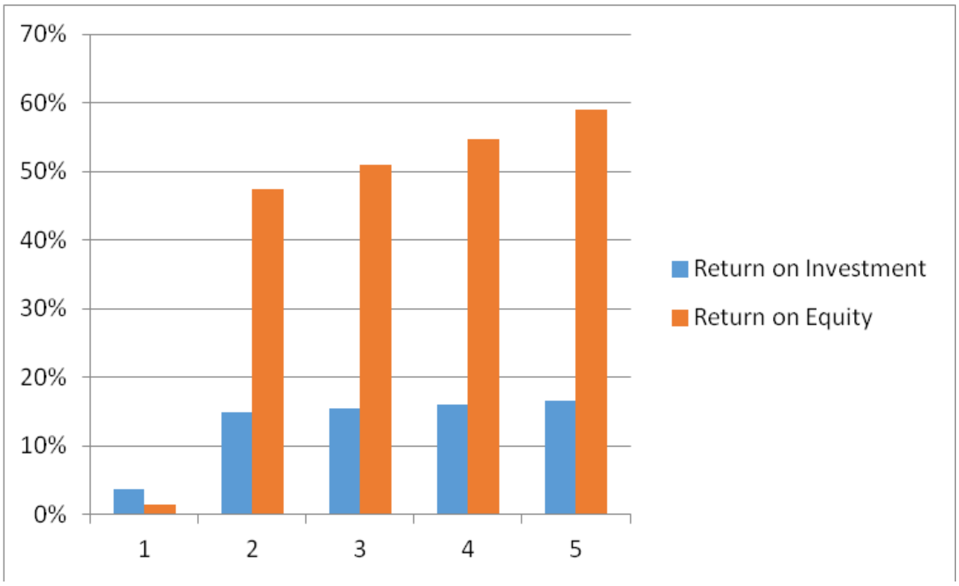


Figure 8. Returns on Investment and Returns on Equity



8.4. Break-even analysis

The results of the break-even analysis, are presented in Table 9. Break even yield reflects the minimum yield per 0.1 ha (stremmas) needed to yield positive net profits. The Break-even price, on the other hand reflects the minimum price that the company needs to achieve in order to cover the variable cost of production. The price and yield of the Hydro-Tomato company is much higher than the break-even price and yield.

Table 9. Break-even Analysis

Year	*1*	*2*	*3*	*4*	*5*
Break even yield (tons/0.1 ha)	260,795	270,201	266,897	263,592	260,288
Break even price (€/kg)	0.46	0.49	0.49	0.49	0.49

8.5. Investment analysis

The Net Present Value of the investment (assuming 10% discount rate) is equal to 152,770 €. This level of the NPV clearly demonstrates the attractiveness of this investment. The high level of this index is also the outcome of the fact that 50% of the investment is state financed (Measure 6 of the Greek Rural development program).

9. Conclusions

This business plan focuses on the establishment of a modern hydroponic greenhouse for the production of tomatoes destined for the domestic market. The business name is HydroTomato and its location is in the Municipality of Trifylia, Peloponnesus.

The initial cost of investment involves mainly the construction of the greenhouse and the purchase of the necessary equipment. As indicated in the business plan, the proposed investment is very attractive and produces positive profits and income. Despite the fact that the level of the initial investment for this business is high, the farmer can benefit from current development programs and receive funding. This case is indicative of the opportunity development programs offer to many people, especially young, who live in rural areas to invest in the primary sector.

Appendix II

BUSINESS PLAN 2

Background information
7. Business name: Viotia-Lettuce
8. Location: Viotia
9. Economic Sector: Fruits and Vegetables.
10.Farming operations: Cultivation of Iceberg, Lollo Rosso and Romana Lettuce
11.Establishment Year: 2016.
12.Type of ownership: family-owned agricultural business

Executive Summary

The company and the product

Viotia-Lettuce is a family-owned agricultural business that utilizes 1 hectare of farmland to produce three varieties of Lettuce, i.e. Iceberg, Lollo Rosso and Romana. The company seeks to specialize in the production of Iceberg, and thus, it aims to increase its cultivated land and alter its cultivations portfolio in favor of Iceberg production during the first five years of operation. Specifically, in the first year of operation, Iceberg occupies 40% of the farmland (0.4 hectare). Until the fifth year of operation, the farm gradually increases its total cultivated land to 1.5 hectares, in favor of Iceberg which occupies 60% of the farmland (0.9 hectares). The cultivation portfolio has been carefully selected to achieve low risk in the economic outcomes of the farm.

The Viotia-Lettuce utilizes family labor in the production process. However, to meet the labor needs of the production cycles of the five cultivations, the farm will hire seasonal daily workers.

Competitive advantages

1. Effective production portfolio that ensures low risk and a fair family farm income.

2. Strategic Location, that lowers shipping costs

The Market

Viotia-Lettuce targets solely the Greek domestic market, and mainly the wholesalers of the central market of Athens. After the company ensures that all production is absorbed by the central market, Viotia-Lettuce will seek for new agreements, that will allow the increase of the production and a growing share in the domestic market.

The Viotia-Lettuce company has to operate in a competitive environment, only in the case of Romana lettuce, as many family farms produce lettuce in areas around Athens neighborhood. In the case of Iceberg and Lollo Rosso, there are significant shortages in the domestic market, while, on the other hand, there is room for exports to several central Europe markets.

The domestic market is traditionally large, as the consumption of lettuce, and especially Romana is very high in Greece. However, as it is already mentioned, there are significant changes in the market during the last few years, mainly due to the entrance of greenhouse lettuce cultivations that provide large volumes of produce during the winter season.

Financial plan

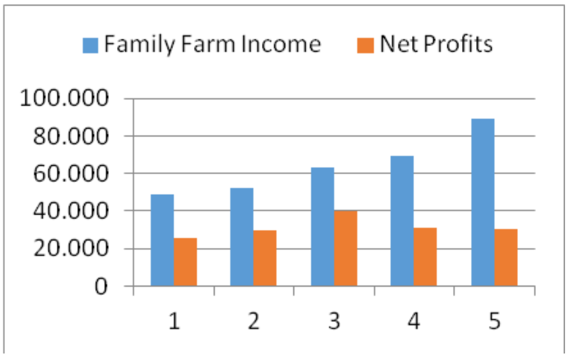
The start-up budget for investing in lettuce production, is relatively low (about 42.000 €). On the other hand, the annual production costs for the first five years of operation are increased, mainly due to the variable costs that constitute 63% of total costs. Variable costs are mainly generated by the cost of purchasing nursery plants as well as packaging and shipping costs.

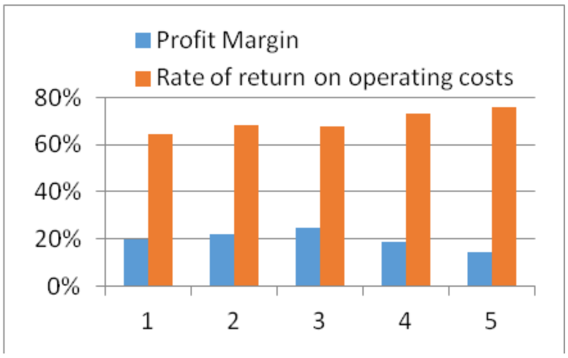
Economic Results

From the first year of operation, Viotia-Lettuce presents positive Net Profits, and very high Family Farm Income, an important index in agricultural economics. In addition, the profit margin and the return on operating costs are also positive and reveal the attractiveness of the investment. Moreover, the level of break-even price is easily achievable according to the plan, and therefore the Viotia-Lettuce, can produce significant profits. Finally, the sensitivity analysis suggests that there is a low risk of economic failure caused by production losses, a factor that can significantly affect economic outcomes of lettuce farms.

Forecasts of Net Profits and Family Farm Income of the operation

Forecasts of profit margin and Rate of return on operating costs.





10. Company Summary

Viotia-Lettuce is a family farm business that produce various type of lettuce varieties to cover the needs of the domestic market. It utilizes one hectare of land in the area of Viotia and produces Iceberg, Lollo Rosso and Romana lettuce varieties. Apart from the land, the ViotiaLettuce farm owns a small building of 100 square meters that includes space for the packaging process, a small office, and a cold room for the storage of the daily harvest.

Mission

The mission of the farm is the production of high-quality heathy and tasteful Iceberg, Lollo Rosso and Romana lettuce for domestic consumption.

Objectives

The objective of the farm is mainly the establishment of an intensive lettuce cultivation farm, specialized in Iceberg production. The company also aims to settle in the domestic market and expand its market share.

11. Company targets

During the establishment of the farm, the cultivation of Iceberg covers 40% of the farmland. It is the farm's target to gradually increase its Iceberg cultivated land to 0.9 ha by increasing its total cultivated land to 1.5 ha. This time frame is necessary for the manager to promote the company in the market and to make strategic agreements with byers that need large Iceberg quantities throughout the year. The increase of the share of Iceberg in production is counterbalanced with a deduction of the more traditional "Romana" variety, which is cheaper and less productive. On the other hand, the "Romana" cultivation is well-known in the area, and therefore there is an increased know-how in its production process. For this reason, Viotia-Lettuce will collaborate with an agriculturalist, expert in Iceberg production, who will provide external service to the company. As far as the Lollo Rosso variety is concerned, it maintains a stable share of the arable land (20%).

During the first year of production, the company targets to distribute the produce to the Central Market of Athens, from October till June. The agreement with wholesalers in the central market of Athens may not guarantee the maximum producer price, but ensures the absorption of its total production. This is a key factor of the marketing strategy of the farm. Viotia-Lettuce will then seek for new agreements, that will allow the company to settle in the domestic market and expand its market share.

12. Start-up Finance

The necessary capital for the start-up of this agricultural business is relatively low. The initial investment involves a small prefabricated building of about 100 square meters that includes a place for the packaging process, a small office, a cold room for the storage of the daily harvest. Moreover, the initial investment includes the acquisition of the irrigation system (drip-irrigation and a fertigation system for nutrients intake). In practice, the start-up period lasts less than a month, and include the land preparation, the establishment of the irrigation system, and the set up and furnishing of the prefabricated building. As the total cost is relatively low (about 40,000 €), the company does not need a bank loan to raise the necessary capital and therefore the project can be self-financed.

13. Key to success

There are two main competitive advantages of the Viotia-Lettuce company that promote its success:

1. Effective production portfolio.

The portfolio of the cultivations ensures low risk and a fair family farm income. The Romana variety has a very large market in Greece, and therefore its promotion to the market can be regarded as certain. Additionally, the Iceberg and the Lollo Rosso products have a special distinct market, which presents a significant shortage during the year and therefore it is expected that the produce can be easily distributed in the market channels at a high producer price.

2. Strategic Location

The location of the farm is in a traditional agricultural area with a significant know-how in the cultivation of lettuce. Moreover, it is very close to Athens and therefore the shipping costs to the central market are very low.

14. Market Analysis

5.1 Market segmentation

Viotia-Lettuce targets solely to the Greek domestic market, and mainly to the wholesalers of the central market of Athens. In order to achieve this, the manager intends to invest in personal communication with selected wholesalers and in the promotion of the produce. After the fully absorption of the produce is ensured, Viotia-Lettuce will seek for new agreements, that allow the increase of the production and that will allow the company to settle in the domestic market and expand its market share.

5.2 Location of the farm

The location of the farm is in an agricultural area, close enough to the central market of Athens and to the main national road that connect Athens with Thessaloniki. Moreover, the location of the farm is characterized by a favourable climate, suitable for the production of lettuce.

5.3 Competition

As far as the Romana variety concerns, the Viotia-Lettuce company has to operate in a competitive environment, as there are plenty of small or medium-sized family farms that produce lettuce in areas close to Athens. Moreover, there is an increasing trend for greenhouse production of lettuce during the winter. The greenhouse cultivation allows for multiple productions during the winter, due to the shortened production cycle.

However, in the case of Iceberg and Lollo Rosso, there are important shortages in the domestic market, while, on the other hand, Iceberg can be exported to several central Europe markets.

5.4 Market structure

The domestic market is traditionally large, as the consumption of lettuce, and especially Romana, per person is very high in Greece. However, as it is already mentioned, the market has undergone significant changes during the last few years, mainly due to the appearance of greenhouse lettuce cultivations that provide large volumes of produce during the winter season.

Suppliers Power: In the area of Viotia, there are plenty of agricultural stores, where farmer can purchase the necessary inputs for the production of lettuce. Furthermore, the farmer can purchase agricultural inputs at favourable prices, since competition amongst suppliers works in his favour.

Buyer Power: A structural problem of the primary sector in Greece is that wholesalers impose producer prices since they have significant bargaining power. However, the increased volumes and the quality of the production of the Viotia-Lettuce will allow the company to achieve better producer prices, especially for the Iceberg and Lollo Rosso varieties.

5.5 SWOT ANALYSIS

Strengths	Weaknesses
• Strategic location that leads to very low shipping costs. • Efficient Production portfolio, that lowers risk and ensure a significant family farm income. • Large production that gives farmer bargaining power • Collaboration with an expert who helps the firm in its production process an ensure quality and quantity standards	• Slow production cycle during the winter, relative to greenhouse farms • Low price of Romana lettuce • High variable costs relative to other traditional cultivation in Greece • The cultivation of Iceberg is relatively new and therefore, the farm needs expert's advice.
Opportunities	**Threats**
• The rising market for Iceberg • The opportunity to export Iceberg produce	The market is highly competitive due to: • Imports of cheap low-quality produce • Appearance of newcomers in the greenhouse lettuce production

15. Products and production process

6.1 Product description

Viotia-Lettuce produces three different lettuce varieties (Iceberg, Lollo Rosso and Romana) but it aims to gradually specialize in the Iceberg production. Therefore, the area cultivated with iceberg increases within the five-year period, the Lollo Rosso cultivated land also increases, while the area covered with Romana decreases. Allocation of the cultivated area of the farm is presented in Table 1.

Table 1. Allocation of the cultivated area (hectares).

Year	*1*	*2*	*3*	*4*	*5*
Iceberg	0.4 (40%)	0.5 (50%)	0.6 (50%)	0.72 (60%)	0.9 (60%)
Lollo rosso	0.2 (20%)	0.2 (20%)	0.24 (20%)	0.24 (20%)	0.3 (20%)

Romana	0.4 (40%)	0.3 (30%)	0.36 (30%)	0.24 (20%)	0.3 (20%)
TOTAL AREA	1	1	1.2	1.2	1.5

Moreover, Table 2 presents the annual expected yields of Iceberg, Lollo Rosso and Romana of the Voiotia-Lettuce. It should be noted that the farm produces in total six products, since for each lettuce variety, there are two quality classifications. The products of extra quality, have all the desired characteristics in terms of size, and appearance. Quality B products present shortfalls in one or more quality characteristics. Average losses, are estimated at 10% in the case of Iceberg and Lollo Rosso, and 20% in the case of Romana.

Table 2. Viotia-Lettuce expected yields.

Year	1	2	3	4	5
Iceberg extra quality (no. of plants)	129,600	162,000	194,400	233,280	291,600
Iceberg lower quality (no. of plants)	32,400	40,500	48,600	58,320	72,900
Lollo extra quality (no. of plants)	64,800	64,800	77,760	77,760	97,200
Lollo lower quality (no. of plants)	16,200	16,200	19,440	19,440	24,300
Romana extra quality (no. of plants)	115,200	86,400	103,680	69,120	86,400
Romana lower quality (no. of plants)	28,800	21,600	25,920	17,280	21,600

6.2. Description of the production process and the equipment needed

The production process follows the guidelines for the production of certified products according to the Integrated Crop Management standards. The plants are purchased from a propagation unit. The on-farm production process includes apart from planting and harvesting, the following activities:

- Plowing: one per year
- Disking: one per product cycle
- Fertilizer: once per week using a fertigation system
- Irrigation: the demand for irrigation is particularly high in the case of lettuce. The frequency and the duration of irrigation are characterized by seasonal variations.

- Pest and Disease control: about 3 to 4 applications per production cycle. Typically, during spring, summer and autumn, two insecticides and one fungicide applications are needed. Additionally, during the winter, one to two and two applications of insecticides and fungicides are required respectively.
- Weed control: it is performed mechanically and presents seasonal variations

Details on the production process can be found in Section 4 of the Sectoral Study 5. Finally, the necessary inputs for the production process (like nursery plants, fertilizers, pesticides etc.) are supplied by local suppliers.

6.3 Personnel

The Viotia-Lettuce is a family business that utilizes family labor for the production process. The owner is responsible for the management of the farm and also offers physica labor throughout the year.

However, the company uses extra hired labor to cover seasonal needs of the cultivations. Personnel costs are presented in Table 3.

Table 3. Annual personnel cost of the farm (€)

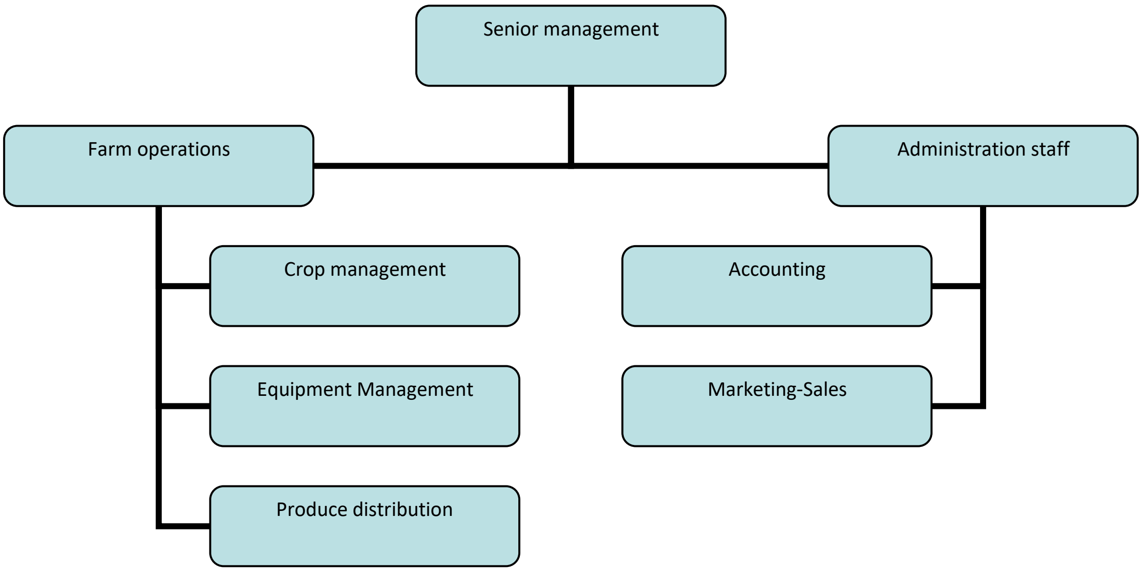
Year	*1*	*2*	*3*	*4*	*5*
Manager (Owner)	15,000	15,000	15,000	15,000	15,000
Daily wages to unspecialized labor	15,200	15,200	19,520	19,520	26,000
TOTAL	30,200	30,200	34,520	34,520	41,000

6.4 Organizational plan

The owner of the company is responsible for the senior management of the farm. Specifically, the owner overseas and participates in all farm operations, but is also responsible for the marketing strategy of the farm.

The company collaborates with an external accounting provider and an agriculturalist who specializes in lettuce production. The agriculturalist pays weekly visits to the farm and offer advice on crop management issues. Seasonal workers are required for specific farm operations like harvesting and packaging. Finally, the distribution of the produce is sub-contracted by a local shipping company.

Figure 1. Organizational plan



16. Marketing strategy according to the marketing mix

7.1 Sales strategy

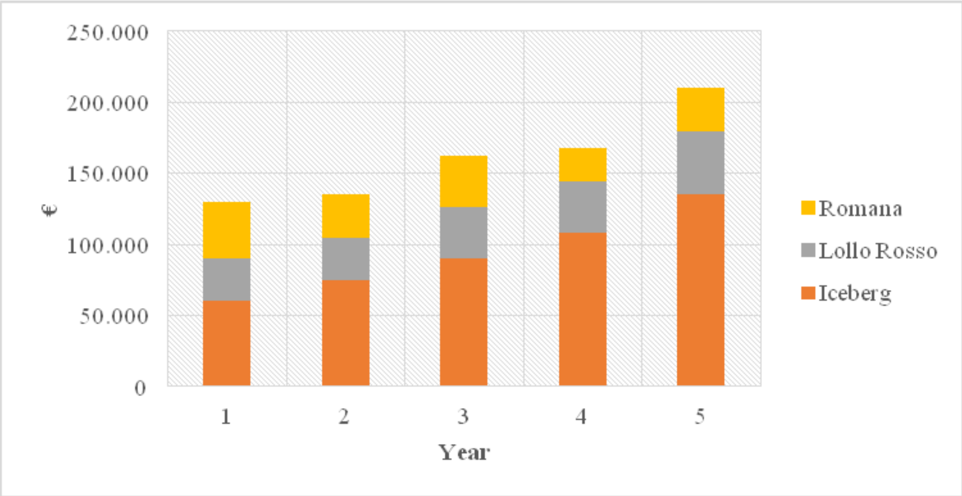
According to the market research, the expected average prices for Iceberg, Lollo Rosso and Romana, are presented in Table 4.

Table 4. Viotia-Lettuce expected prices.

	Price (€/unit)
Iceberg extra quality (no. of plants)	0.4
Iceberg lower quality (no. of plants)	0.2
Lollo extra quality (no. of plants)	0.4
Lollo lower quality (no. of plants)	0.2
Romana extra quality (no. of plants)	0.3
Romana lower quality (no. of plants)	0.15

Given the producer prices and the expected production (see also Table 3), the sales forecast is presented in Figure 2.

Figure 2. Sales forecast



7.2 Distribution strategy

The produce will reach the central market of Athens, via an external partnership with a shipping company. Given the distance from Athens and condition of the road network, the transportation costs are expected to be about 0.03 € per plant.

7.3 Marketing Strategy

The company will cover a cost for the promotion of each product in the first year of its operation. This cost is estimated at 10,000 and it is basically covers the cost of the company's identity development and specifically:

- the design of its logo,
- the development of its website,
- personal communications with selected wholesalers in the central market of Athens,
- registration of the company in professional yellow pages and
- advertising in newspapers and other agricultural related magazines.

The logo will be printed on the company's cardboard boxes, stationery and invoices so that the clientele can easily identify the company. The website and the registration in the professional yellow pages enables potential customers to communicate with the company. Finally, advertising and personal communication with selected wholesalers is necessary so that the company can approach its clientele. After the first year of operation, promotion will be cut down to 2,000 €.

17. Financial Plan

8.1. Start-up investments

Table 5 presents the start-up budget for the investment, which is about 42,000 €. The main part of the budget regards the establishment of the irrigation system, the setup of the prefabricated building and the purchase of the cold room.

The farm uses contract labor for all farm operations like plowing and disking. Since the investment is self-financed and the purchase of other equipment and machinery would increase initial cost.

Table 5. Start-up budget (€)

Drip irrigation and fertigation system	10,250
Cold room	14,000
Prefabricated building	15,000
Office equipment	2,000
Other cost	1,000
TOTAL	40,250

8.2. Annual production costs

Table 6 presents the annual production costs for the first five years of operation. According to Figure 4, the main part of the annual costs regards the variable costs (65%), while labor costs refer to 23% of the total production cost. Variable costs are mainly generated by the cost of purchasing nursery plants as well as packaging and shipping costs, (Figure 5).

Figure 4. Annual cost breakdown

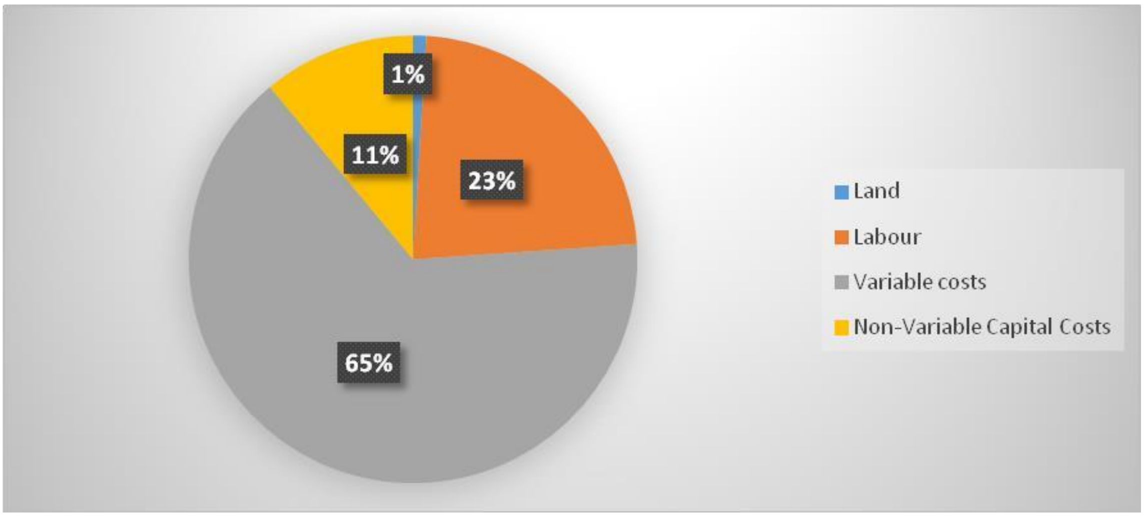
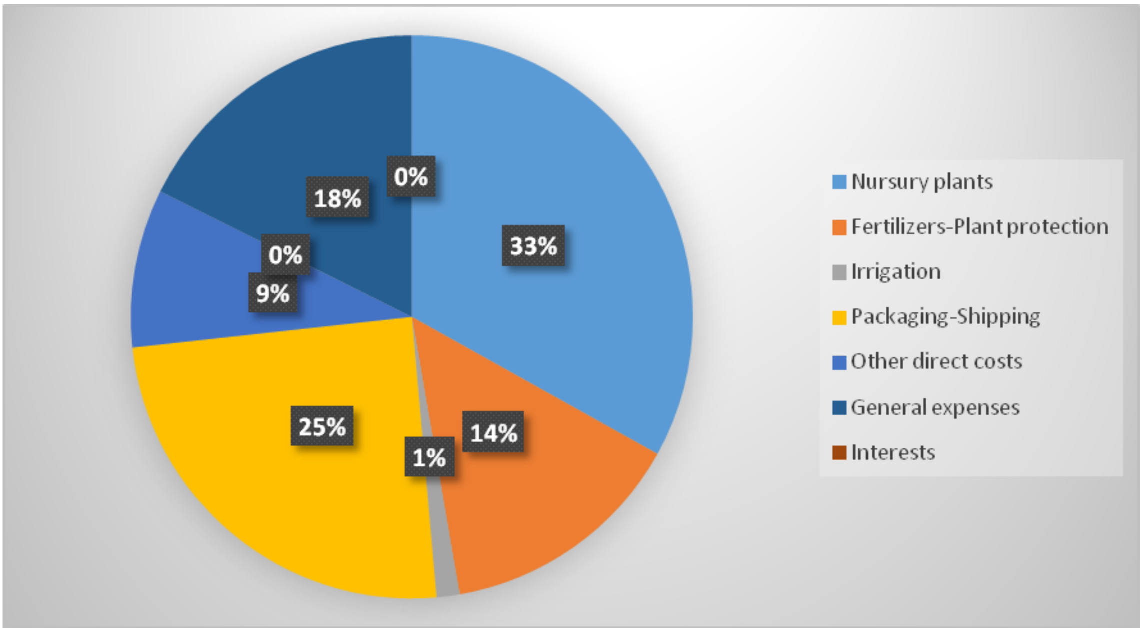


Table 6. Annual costs

Year	1	2	3	4	5
Land	1,000	1,000	1,200	1,200	1,500
Labour	24,000	33,600	38,400	38,400	45,60 0
Permanent	16,000	16,000	16,000	16,000	16,000
Seasonal	8,000	17,600	22,400	22,400	29,600
Capital Costs	79,539	70,810	82,696	97,128	132,498
Variable costs	68,002	59,417	70,420	70,677	85,069
Nursury plants	22,500	22,500	27,000	27,000	33,750
Fertilizers-Plant protection	9,650	9,650	11,580	11,580	14,475
Irrigation	900	900	1,080	1,080	1,350
Packaging-Shipping	16,770	16,965	20,358	20,592	23,760
Other direct costs	6,182	5,402	6,402	6,425	7,734
General expenses	12,000	4,000	4,000	4,000	4,000
Non-Variable Capital Costs	11,537	11,394	12,276	26,451	47,429
Depreciation	3,065	3,065	3,256	3,256	3,521
Insurance	321	309	311	298	291
Maintenance	1,162	1,116	1,125	1,076	1,053

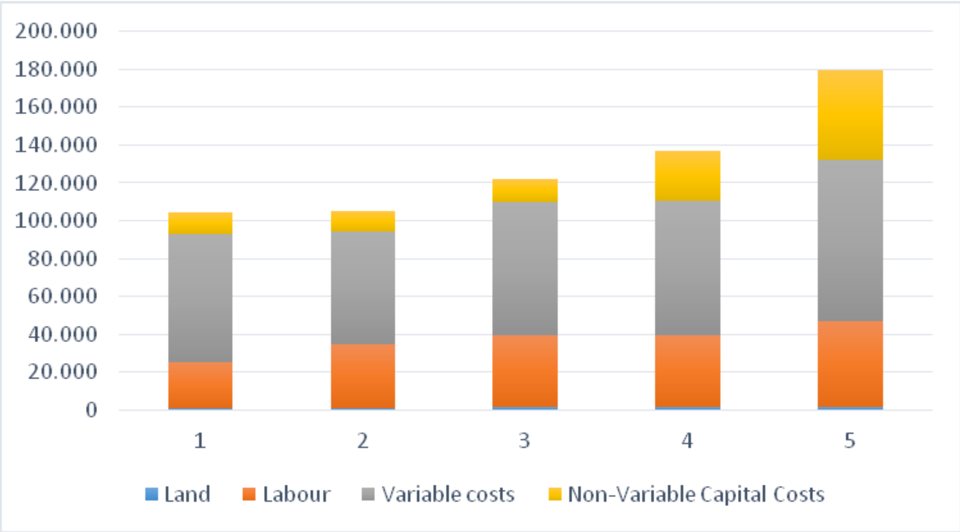
Interests	6,989	6,905	7,583	21,821	42,564
TOTAL	**104,539**	**105,410**	**122,296**	**136,728**	**179,598**

Figure 5. Breakdown of variable costs.



Finally, Figure 6 depicts annual costs per year of operation. Annual costs are slightly increasing, following the expansion of the farmland in the third and fifth year of operation. It is important to emphasize that the contribution of each cost item to the annual costs is almost stable.

Figure 6. Annual costs for the first five year of the investments.



8.3. Economic results

Table 7 presents the economic indices for the farm. Viotia-Lettuce presents positive Net Profits, and very high Family Farm Income (FFI), an important index in agricultural economics (see also Figure 7). FFI indicates the remuneration of the production factors that are owned by the family; thus, it is a measure of the family's welfare. A positive and high FFI points out the economic sustainability of the family farm business. FFI is calculated as the sum of the net profit, the implicit rent of the farmland, the implicit cost of family labour and the opportunity cost of family-owned capital (interests). Finally, the profit margin and the return on operating costs are also positive and reveal the attractiveness of the investment (see also Figure 8).

Figure 7. Net Profits and Family Farm Income of the operation

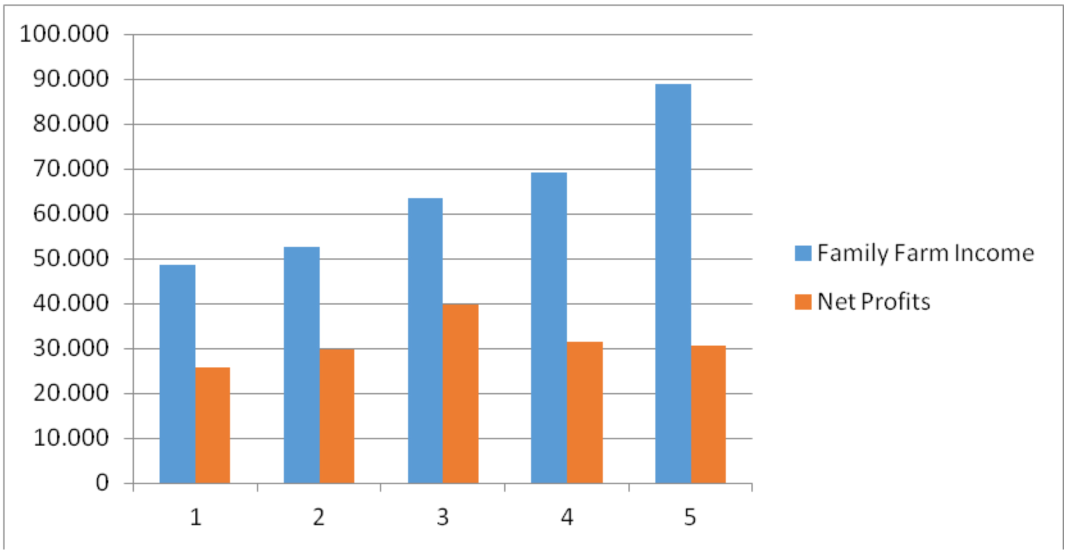


Figure 8. Forecast for profit margin and Rate of return on operating costs.

Table 7. Economic indices per year

Year	*1*	*2*	*3*	*4*	*5*
Sales forecast	130,230	135,135	162,162	168,048	210,06 0
Variable costs	79,137	154,151	154,151	154,151	154,151
Non-variable costs	25,402	120,092	118,718	117,345	115,972
Explicit costs	78,164	201,595	199,674	197,640	195,487
Implicit costs	26,375	72,647	73,195	73,856	74,636
Total expenses	104,539	274,24 2	272,869	271,496	270,123
Gross Profit	51,093	150,489	150,489	150,489	150,489
Profit (excl. tax, depreciation, interests)	35,745	95,660	96,088	96,517	96,946
Family farm income	48,681	72,491	74,524	76,669	78,935
Net profit	25,691	30,398	31,771	33,144	34,517
Profit Margin	19.73%	9.98%	10.43%	10.88%	11.33%
Rate of return on operating costs	64.56%	14.91%	15.45%	16.02%	16.63%

8.4. Break-even analysis

The results of the break-even analysis, are presented in Table 8. Break-even price reflects the minimum price that the company needs to achieve in order to cover the variable cost of production. In the case of the Viotia-Lettuce company the price of all varieties surpass the corresponding break-even points.

Table 8. Break-even Analysis per year.

	1	2	3	4	5
break even price iceberg	0.19	0.20	0.20	0.20	0.20
break even price Lollo	0.19	0.20	0.20	0.20	0.20
break even price Romana	0.22	0.22	0.22	0.22	0.22

8.4. Sensitivity analysis

Agricultural production is characterized by increased risk and uncertainty as yields are highly vulnerable to the weather conditions and to pests and diseases. To assess the impact of reduced yields on the economic results of Voiotia-Lettuce company, a sensitivity analysis is performed (Table 9 and 10). The results indicate that losses in production significantly affect Family Farm Income and Net Profits. However, almost all scenarios create positive levels of Family Farm Income and Net Profits. These results indicate that Voiotia-Lettice company has low risk of economic failure.

Table 9. Sensitivity analysis on the effect of production losses to the Family Farm Income.

Production losses scenarios	*1*	*2*	*3*	*4*	*5*
10% losses for Iceberg and Lollo Rosso and 20% losses for Romana	48,135	52,092	62,919	68,618	88,511
20% losses for Iceberg and Lollo Rosso and 40% losses for Romana	31,068	35,665	43,207	49,675	64,535
30% losses for Iceberg and Lollo Rosso and 60% losses for Romana	14,001	19,239	23,496	30,731	40,559
40% losses for Iceberg and Lollo Rosso and 80% losses for Romana	-3,066	2,812	3,784	11,788	16,583

Table 10. Sensitivity analysis on the effect of production losses to the Net Profit.

Production losses scenarios	*1*	*2*	*3*	*4*	*5*

10% losses for Iceberg and Lollo Rosso and 20% losses for Romana	25,939	46,310	40,247	46,065	65,154
20% losses for Iceberg and Lollo Rosso and 40% losses for Romana	8,977	13,652	20,652	27,229	41,302
30% losses for Iceberg and Lollo Rosso and 60% losses for Romana	-7,985	-2,677	1,058	8,394	17,451
40% losses for Iceberg and Lollo Rosso and 80% losses for Romana	-24,947	-19,005	-18,537	-10,441	-6,400

18. Conclusions

Viotia-Lettuce is a newly developed farm family business that aims to invest in the production of various lettuce varieties, with a specialization on the production on Iceberg. The business plan demonstrates that the proposed investment is attractive, as it produces positive profits and income. The attractiveness of this investment is also reflected by the level of profit margin and Rate of return on operating costs. Apart from Iceberg the farm also aims to produce Lollo Rosso and Romana. The relatively low initial cost of investment, the high production yields of the lettuce varieties and the increased market demand are key success factors for the farm.